

Proceedings of the International Conference on Innovation - driven Knowledge Economies and Transformation in the Global South

Proceedings of the International Conference on Innovation - driven Knowledge Economies and Transformation in the Global South

Volume VIII

Innovation for Inclusive Development: Indigenous knowledge, Grassroot Innovations, Jugaad, informal Economy, Micro and Small Enterprises

11-14 OCTOBER 2023

Organized by

GLOBELICS | Gulati Institute of Finance and Taxation | Research and
Information System for Developing | Indian Institute of Management
Bangalore | Kerala Development and Innovation Strategic Council



Preface / A word of welcome and thanks

It is a matter of great pride that the 20th-anniversary Globelics International Conference is being held in Thiruvananthapuram. This conference deliberates on an issue of much contemporary relevance – Innovation-driven Knowledge Economies and Transformation in the Global South, which is at the centre stage of development strategy both at the national and that of the government of Kerala. In 2006, when inclusive development was a major issue of global concern, Globelics conference was held in Trivandrum and deliberated on Innovation Systems for International Competitiveness and Shared Prosperity.

This Conference intends to bring together scholars across disciplines from over 50 countries to pool together experiences and expertise to reflect on varied issues involved in the process of transforming developing economies into sustainable, resilient, and inclusive innovation-driven knowledge economies.

In the conference, to be inaugurated by Shri Pinarayi Vijayan, the Hon'ble Chief Minister of Kerala, scholars of eminence will join as keynote speakers and panelists in plenary sessions and special sessions. The conference, organized in nine parallel tracks, will also have book presentations, excursions, and cultural events. As part of the conference, about 20 leading scholars from Globelics will visit different universities and colleges in Kerala to deliver lectures and interact with faculty and students, which is facilitated by Kerala Higher Education Council and Kerala Economic Association.

We welcome with great appreciation the Honourable Chief Minister Shri Pinarayi Vijayan and all the dignitaries who joined us for the inaugural address and eminent scholars delivering keynotes and addressing in different plenary sessions, special sessions, and parallel sessions. While the invisible hand of our honourable Chief Minister is there in all the important initiatives of GIFT, this program has been ably guided and steered by our Chairperson Shri K N Balagopal, Hon'ble Finance Minister of Kerala.

This important event is the outcome of the collective effort of all those involved, especially the Co-organising institutions: RIS, New Delhi, who inter alia managed the political clearance from the Ministry of External Affairs, IIM Bangalore, K DISC and the Digital University of Kerala. Our partnering institutions, ICSSR, Kerala State Higher Education Council, Centre for Development Studies, Kerala Economic Association, and the Centre for Latin American Studies also have been helpful in organising this conference.

With much appreciation for all of you for being with us, we welcome you

K J Joseph

For the local organising Committee

About the 20th Anniversary Conference

The central theme of the 20th Anniversary Globelics International conference is Innovation-driven Knowledge Economies and Transformation in the Global South.

This conference intends to bring together scholars across disciplines from over 50 countries to pool together experiences and expertise to reflect on varied issues involved in the process of transforming developing economies into sustainable, resilient, and inclusive innovation-driven knowledge economies. Episodes of development in economic history highlight the successful experience of countries that have managed to harness Learning, Innovation and Competence-building Systems at the global, national, subnational and sectoral levels in order to transform their social and economic structures for achieving prosperity. In the current times, the constellation of innovations driven by rapid advances in digital technologies has given rise to a new technological revolution, commonly referred to as the fourth industrial revolution, or Industry 4.0, with profound impacts on all sectors of the economies and sections of societies. New and persisting developmental challenges have driven a renewed interest in different types of innovations that highlight their impact on society and the natural environment, such as inclusive innovation, responsible innovation, transformative innovation, grassroots innovation and Jugaad. At the core of all these approaches is how knowledge, both science-based and experience-based, is harnessed for addressing development challenges, the basic premise being “the knowledge divide is at the root of the development divide”

At the current juncture, wherein globalization is at the crossroads, the economies across the world, ravaged by the once-in-a-century pandemic and external shocks, consider strengthening the innovation system as a strategic approach towards building resilience. Evidently, there is an across-the-board drive among developing countries to transform their economies into innovation-driven knowledge economies. Such a transformation is often viewed as capable of building resilience by addressing many of the downsides of globalization-induced high growth, like excessive exploitation of exhaustible resources and accentuated divides within and between countries. Such

initiatives in India are manifested, among others, in Atal Innovation Mission (AIM), Digital India, Skill India, and Make in India and other concerted efforts to transform India into an innovation-driven knowledge economy. It is also in sync with the national agenda of harnessing Science, Technology, and Innovation (STI) to achieve sustainable development. The choice of the location of the conference is inspired by Kerala's strategy towards transforming the state into a knowledge economy, as explicitly stated in the budgets starting with 2020-2021 and the subsequent concerted efforts that followed. It is in this background that Globelics revisits India for the 20th Globelics International conference with the chosen central theme: 'Innovation-Driven Knowledge-Economies and Transformation in the Global South'.

The 20th Anniversary Globelics is also an occasion to celebrate the journey of Globelics from Brazil 2003 to India 2023 and its varied achievements. At the same time, it is also a forum for critically reflecting on our perspective and the approaches *inter alia* in terms of its achievements and limits. This is especially important at the current juncture wherein there is growing disenchantment with the development experience under globalisation on the one hand and the need on the other hand, for reimagining innovation systems in the COVID and Post COVID world towards building the much needed resilience in the South.

Globelics-India 2023 coincides with India's Presidency of G-20 that *inter alia* aims at influencing the development dynamics of Global South and it is an appropriate time for translating the insights of the conference with respect to strengthening Learning, Innovation and Competence-building Systems (LICS) into policy action. For the past two decades, we have observed an increasing influence of Global South in shaping the paradigms and trajectories of the global development agenda—sustainability, climate change, pandemic, and energy security issues—with India playing a key role; all being closely linked to the research domains of the Globelics.

World-leading scholars are set to give this year's keynote address on innovation and development. It is planned that the conference will be inaugurated by the Chief Minister of Kerala and there will be a special keynote on the conference theme along with a Globelics Lecture and Freeman Lecture. The conference will combine plenary sessions, presentations of research papers in parallel tracks, thematic panel sessions or special sessions, poster presentations, book presentation sessions, excursions, and cultural events.

Conference Tracks

While submissions on the central theme of the conference have been especially encouraged, submissions on all the issues conventionally deliberated in the Globelics international conferences are also included. Submissions have been organized around the following themes:

1. Science, technology, innovation: Theory and policy for a knowledge economy
2. Transformative innovation, responsible innovation and mission-oriented innovation
3. Knowledge-driven development of national, regional, local and sectoral innovation systems, including Agricultural innovation systems and rural development
4. Measurement of the knowledge economy: Indicators, data requirements, different approaches and methodologies
5. Skilling for the knowledge economy: Industry-academy interaction, Intellectual property rights, open innovation and development
6. Industry 4.0 and development: Digitalization and automatization, productivity and employment implications, gig economy and quality of employment
7. Economic and social upgrading for sustainable Catch-up: trade policies, FDI, value chains and innovation networks in a knowledge-driven economy
8. Innovation for inclusive development: Indigenous knowledge, Grassroot innovations, Jugaad, informal economy, micro and small enterprises
9. Entrepreneurship, employability and gender dimension in innovation and development
10. The green economy and financing innovation: Low carbon innovations, environmental technologies and renewable energy

Volume VIII
Innovation for Inclusive Development: Indigenous
knowledge, Grassroot Innovations, Jugaad, informal
Economy, Micro and Small Enterprises

Contents

	Page No
Preface	V
About the 20th Anniversary Conference	VII
Conference Tracks	IX
1 Gendered agglomeration and innovation dynamics M. Samson C. Aklobo , Bernadin G. C. Ahodode	1
2 Innovations and Firm Performance in Informal Manufacturing Enterprises: Field-based Evidence from India Caleb Adelowo ,Seun Adedeji	32
3 A quantitative analysis of obstacles to innovation among small, micro, and medium- sized enterprises: evidence from South Africa Siyasanga Qomoyi	54
4 Comparative Case Studies of the Industrial Transformation of the Pharmaceutical innovation system in Taiwan and India Shih-Hsin Chen, Hung-Chi Chang, Wen-Hsin Chi	78
5 Building Medical Device Innovation System in Taiwan and India (2001-2021) Shih-Hsin Chen、 Wen-Hsin Chi、 Hung-Chi Chang	111
6 Endogenous Knowledge and Secondary Innovation in the age of COVID-19: A Global South Civilisational Dialogue Ogundiran Soumonni, Mammo Muchie	148
7 Indigenous Technology, Innovation and Inclusive Development: A Study of the Silk Reeling Sector of Jammu and Kashmir Priyanka Sharma	170
8 Innovation in the informal sector: towards inclusion in alternative development pathways Ii-haam Petersen,Glenda Kruss	196

9	Is small always beautiful? Heterogeneous effects of small scale de-reservation on product scope and performance George Paily, Nanditha Mathew, Carlo Pietrobelli	234
10	Rule of Extractive Informal Institutions in Democracy: Implications for Regional Disparity in Odisha Laxmikanta Gual	265
11	Craft industry in Nova Scotia and Inclusive innovation Fariba Seyedjafarrangraz, Claudia De Fuentes	283
12	Incubators and Technology Parks and Sustainable Local Development: Analytical Framework and Evidence in Brazil Marcelo Matos, Maria Cecilia Lustosa, Pedro Rocha Larissa Almeida, Bruna Moll	310
13	The Role of Innovation in Humanitarian Assistance – Systematic Literature Review Maximilian Franz Georg Bruder, Thomas Baar	348
14	Frugal Innovation and the Value Creation Paradox: Creating Shared and Stakeholder Value Ashish Gosain	447
15	Innovation complementarities in small and micro-enterprises in Johannesburg, South Africa Godfrey Paradzai Kamutando, Fiona Tregenna	463
16	Can technological innovations contribute to more overcome the issue of poverty reduction in Africa? Charles Bertin Pilag Kakeu, Clovis Wendji Miamo , Clemence Zite Kouhomou	491
17	Menstrual health, grassroots innovations and social entrepreneurship: Exploring the case of Indian “Pad Man” Kajal Kumari, Hemant Kumar	523

18	Econometrics of Social Interactions: A Way to Study the Social and Solidarity Economies? Maheen Kannu M, Christabell P J	543
19	The Interplay between Innovation Adoption and Pricing Competitiveness in Sub- Saharan Africa Andre Dumas Tsambou, Benjamin Fomba kamga Yannick Fosso Djoumessi	553
20	Analysis of the Functional Dynamics of Innovation for Inclusive Development Systems: An Event History Analysis of the Nigerian Growth Enhancement Support Scheme David Adeyeye, Sara S. Grobbelaar	581
21	Social Enterprises in Malaysia: Understanding Typology, Ecosystem and Sustainability Angathevar Baskaran, Theresa S.Y.Chan. VGR Chandran Sonia Kumari Selvarajan	619
22	Household Innovation in South Africa: Treading new ground in entrepreneurship development? Calory Larr Onyango	653

Gendered agglomeration and innovation dynamics

M. Samson C. Aklobo

Universte de Quebec

Bernadin G. C. Ahodode

University of Abomey-Calavi

Abstract

This study examines the impact of both gender and gendered agglomeration defined as a circumstance in which firms with a given gender composition tend to establish themselves in specific cities - on innovation dynamics in terms of knowledge spillovers in Africa. Our framework considers gender composition of ownership, management and workforce, as well as various types of innovations including, product, process, marketing, aggregate innovation, and R&D. The paper employs an ordered probit and a two-stage Heckman probit models with instrumental variable to address endogeneity issues between gender composition at the firm level and innovation. Using data from the 2016 World Bank Enterprise Survey on 3,921 Africans firms, our study yields four main new findings: (i) the positive effect of, gendered agglomeration, having a female as manager and the proportion of women among both the firm's owners and workforce, is contingent upon the variety of innovations undertaken by the firm, (ii) both male and female agglomeration influence positively innovation dynamics,

(iii) in term of human capital, the nature of the agglomeration does not matter for innovation, and (iv) R&D expenditures decisions are made by the firm's ownership rather than its management.

Key words: Innovation, Gender, Agglomeration, Gendered agglomeration.

JEL Codes : O31, J160, R1, J54.

1. Introduction

Innovation is fundamental for firm's productivity and economic growth. The innovation sector is traditionally characterized by male dominance or gender ignorance (Ranga and Etzkowitz, 2010). Firm's agglomeration into cities determines innovation dynamics (Marshall, 1890). While the relationships between gender and innovation, and agglomeration and innovation have been largely documented, how gendered agglomeration defined as a circumstance in which firms with a given gender composition of ownership/management/workforce tend to establish themselves in specific cities affects firms' innovation is missing. Women entrepreneurs often choose to establish their businesses farther away from urban hubs and have shorter commuting distances in comparison to their male counterparts (Rosenthal and Strange, 2012). This suggests that gender may also impact the geographical distribution of firms, resulting in agglomerations that are either predominantly male or female in nature. Making the dissociation between male and female agglomeration is then crucial for evaluation and design of policies, such as innovation policies and policies related to women participation in economic activities.

Two strands of the literature stem from the links between gender, agglomeration, and innovation. On the one hand, there has been documented a positive relationship between gender diversity and innovation (Ruiz Jimenez et al., 2016; Kristinsson et al., 2016; Torchia et al., 2018). However, promoting male over female may leave some innovative opportunities unexploited (Rees, 2000; Blake and Hanson, 2005; Pettersson, 2007; Nyberg, 2009; Lindberg, 2014). The positive effect of gender diversity may also depends on the type of innovations. For instance, male employment intensive firms may be good on generating technological innovation over organizational or marketing ones (Na'hlander, 2010; Lindberg, 2012; Lindberg et al., 2015; Gallego and Gutierrez Urdaneta, 2018). On the other hand, many studies have investigated the relationship between agglomeration and firms' innovation (Kekezi and Klaesson, 2020; Feldman, 1994; Glaeser et al., 1992). Evidence is controversial in the sense that agglomeration may increase process innovation (through imitation, interactions, access to external knowledge), it may have no influence on product innovation, and it may negatively affect R&D investment (Chen et al., 2020; Fang, 2019; Zhang et al., 2014). The mobility of highly qualified workers represents an important factor whereby knowledge spillovers across different locations materialize (Agrawal et al., 2006; Simonen and McCann, 2008; Grinza and Quatraro, 2019). Since female-owned firms are less exposed to agglomeration matching (Rosenthal and Strange, 2012), gendered agglomeration may likely affect firms' innovation dynamics in terms of local externalities.

Taking insights from the well-known knowledge spillover theory, our study makes both theoretical and empirical contributions. First, we contribute to the literature on gender and innovation by documenting that the beneficial impact of having a female as manager and the proportion of women among both the firm's owners and workforce is contingent upon the innovation diversity present in the firm's innovative activities. Second, we propose a gendered agglomeration and innovation framework that takes into account three gendered agglomeration dimensions, such as, gendered owners agglomerations, gendered managers agglomerations, and gendered employees agglomerations. We explore the idea that the nature of the agglomeration, whether it's predominantly male or female, can lead to varying impacts on the firm's innovative activities. More specifically, gendered agglomeration may affect the traditional agglomeration mechanisms, mainly through knowledge spillover. This in turn may affect differently innovation dynamics. Since innovation activities require knowledge, we take employment as a human capital-augmented labor input and we split human capital into male and female. This enables us to also analyze the effects of male-human capital versus female human capital agglomeration on innovation dynamics. Finally, we carry out an empirical analysis based on the World Bank Enterprise Survey (WBES) data on nine African countries in 2016, with a sample of 3,921 firms both manufacturing and services. Our regressions check how gendered agglomeration affects both the firm's R&D investment decision making and innovation. We used Psacharopoulos and Patrinos (2004)' table on returns to education by gender to compute our measure of human capital. We then propose a gendered agglomeration measure based on the density. Our econometric estimations use both the ordered probit and the two stage Heckman probit models with instrumental variables to overcome endogeneity issues between the gender composition at the firm level and innovation related variables. To the best of our knowledge, this paper is the first to analyze the effect of gendered agglomeration on firms' innovation dynamics.

Our results show that both male and female agglomeration positively affects the firm's innovative activities, as do male and female human capital agglomeration. The marginal effects are equal for both male and female human capital. This says that only the level of human capital (knowledge) matters for innovation, while the gender composition of this human capital does not have any significant effect. In comparison to female owners, we observed that female managers have no significant effect on the firms investment in R&D. To corroborate this finding, we examined the specific case for Africa (and for small firms in general) where the manager holds ownership as well. This suggests that decisions regarding R&D investment are predominantly driven by the firm's ownership rather than its management. Our robustness analysis reveals that the effects of both gender and gendered agglomeration on innovation stay negative for the first and second type of innovations (regardless of the type of innovations) introduced by the firm. However, this effect turns positive starting

from the third type of innovations and becomes even stronger for the fourth type. Hence, the positive impact of gender on innovation is not solely determined by the type of innovations, as previously shown in existing research. Instead, this effect is also influenced by the variety of innovations undertaken by the firm. Our study is relevant not just for innovation-related policies but also for policies regarding gender, inequality and inclusion, as well as women's engagement in economic activities.

The remainder of the paper presents in section 2 the literature review. In section 3, we expose a gendered agglomeration theoretical framework. Section 4 describes the data and the methodology. Section 5 discusses the results while section 6 concludes and proposes some policies recommendations.

2 Theory and hypothesis

2.1 Gender and innovation

A large amount of both theoretical and empirical investigations have highlighted the impact of gender diversity on firms' innovative activities. Nonetheless, prior research has yielded limited results when examining the link between gender diversity and innovation. This is to say that, despite the increased focus on the effect of gender diversity and inclusion on innovation, there has been limited investigation on how gender influences innovation dynamics within the context of local externalities.

Earlier research exploring the influence of gender diversity on firms' innovation dynamics has been conducted within the frameworks of both "doing gender" and "gender mainstreaming". On the one hand, the "doing gender" approach suggests that gender influences innovation through the unequal distribution of resources, power, and status between men and women, as well as between different industries and innovation networks (Blake and Hanson, 2005; Pettersson, 2007; Lindberg, 2014). However, a shift in the "doing gender" approach proposes that industries innovate based on their potential to stimulate creativity and societal development rather than their gendered nature (Andesson et al., 2009; Lindberg, 2012; Lindberg et al., 2015). Conversely, there exists the potential for undoing of gender, whereby the process results in segregating and hierarchical patterns at individual and structural levels, challenging the prevailing trends and perceptions of the world (Deutsch, 2007). Studies following the "doing gender" approach have found that having gender diversity in the board of directors positively impacts firms' innovation by enhancing management capacity, leading to the generation and implementation of new ideas for products and services (Ruiz-Jimenez et al., 2016; Kristinsson et al., 2016). Recent studies have emphasized that firms with more women involved in knowledge creation and the innovation process exhibit improved innovation behavior. However, in developing countries, women's contribution to science, technology, and innovation activities is still limited, and

their participation in manufacturing has a greater impact on technological innovation than on organizational or marketing innovation. Gender diversity also indirectly impacts organizational innovation by promoting cognitive conflict, influencing decision-making culture, and encouraging participation in board meetings (Gallego and Gutiérrez Urdaneta, 2018; Torchia et al., 2018). Integrating innovative employment from services and creative industries can further benefit women dominated professions, but the gender imbalance in male-dominated industries leads to missed opportunities for innovation (Nyberg, 2009; Na'hlinger, 2010; Lindberg, 2012; Lindberg et al., 2015). Manufacturing and technology sectors remain male-dominated industries, creating a hierarchy and segregation between men and women in the field of innovation (Rees, 2000; Blake and Hanson, 2005; Pettersson, 2007; Lindberg, 2014).

On the other hand, the “gender mainstreaming” is a strategy used to address gender inequality by scrutinizing and reinventing policy formation and implementation processes across all issue areas to rectify disparities between women and men. There exists two alternative ways of “mainstreaming gender”, such as, the integrationism and the agenda setting strategies introduced by Walby (2005) while Squires (2005) has identified the inclusion, reversal, and displacement strategies. Our study aligns with the framework proposed by Squires which views “mainstreaming gender” as a displacement strategy, with treatment and positive action seen as inclusion and reversal strategies, respectively. These strategies can be attributed to the three aspects of gender proposed in our analysis, which are the ownership, the management, and the employment. The displacement strategy, which is a form of postmodern feminism, views gender as a verb rather than a noun and embraces diversity politics. This approach deconstructs gender by recognizing it as constantly constructed and changeable, similar to the “doing gender” approach. By challenging hierarchical and segregating gender norms in policies, the displacement strategy promotes greater connections between gender and innovation. This political process aims to counteract gender bias within existing structures and systems for innovation generation by questioning the differential treatment of men and women. The strategy recognizes the importance of understanding how gender affects people’s potential to contribute to creativity and innovation. Recent research from emerging economies suggests that the proportion of women within the firm’s ownership contributes positively to individual and composite innovation, while female top management has a positive effect on marketing innovation. However, the percentage of women employees in the workforce does not significantly impact innovation. Given the displacement strategy’s emphasis on acknowledging diverse identities, visions, norm diffusion, and experiences, we formulate the female workforce-related hypothesis as follows: The firm’s innovative performance depends on the proportion of women among her employees (Hypothesis 1.a).

The reversal strategy is aligned with radical feminism and acknowledges women as a distinct category while promoting difference politics. The key normative issue here is whether gender equality should entail the de-gendering of society or equal valuation of contributions from both men and women. The reversal strategy integrates a gender perspective and positive action by recognizing the differences between men and women and implementing measures to address the disadvantages faced by women due to those differences. Mainstreaming in this context involves the inclusion of women's voices, which can be observed in the comparison between women's and men's management styles. Research shows that firms with male managers tend to have a higher innovative performance than those with female managers, as men are perceived to be more risk-taking and are often credited with more innovative activities. However, it is argued that women managers tend to communicate more frequently and respectfully with male subordinates, are more cooperative and less selfish, and foster team creativity, facilitate information sharing, and mitigate status conflicts within the group. As a result, women's management styles may also enhance firms' innovation dynamics. Given these considerations, we postulate that: Women managers' effect on innovation when significant should be positive and higher for marketing innovation than other innovative activities (Hypothesis 1.b).

The inclusion strategy of liberal feminism emphasizes gender neutrality and views individuals as autonomous, aligning with equality politics. The liberal principles of equity aim to overcome sexist presumptions about gender differences, provide women with equal rights to men, and enable women's equal participation in the public sphere. As a technique or tool for achieving equal treatment, the inclusion strategy employs legal remedies to ensure that men and women are treated the same. "Gender mainstreaming" based on formal equality of opportunities is accomplished through bureaucratic policy processes. Analogously, our study associates women's ownership actions within a firm's board of directors with this form of "gender mainstreaming", as firm owners can also be treated as managers. The literature shows that increasing the representation of women on boards of directors leads to the development of new technologies, increased innovation activities, and R&D expenditures (Dezs o and Ross, 2012; Che and Zhang, 2018; An et al., 2019). Regarding these findings, we propose the following hypothesis: The firm's innovative performance depends on the proportion of women among her owners (Hypothesis 1.c).

2.2 The role of local externalities

Agglomeration economies can emerge from a variety of interactions, such as, those between similar firms, physical input suppliers, and business service providers like bankers. The external conditions specific to a place can affect a firm's economic and innovation dynamics due to technical, pecuniary, and knowledge externalities (Antonelli et al., 2011; Antonelli and Colombelli, 2017).

The literature has highlighted two main types of externalities named Jacobs and Marshall-Arrow-Romer (MAR) externalities (Glaeser et al., 1992). MAR externalities result from the spatial concentration of firms in a particular industry. Spatial proximity can boost a firm's dynamic through input-output linkages, labor market dynamics, and knowledge spillovers (Marshall, 1890). The latter is especially relevant to the connection between gendered agglomeration and firms' innovation dynamics.

Knowledge spillovers models describe the transfer of knowledge between individuals located in close proximity to each other. This proximity is especially beneficial in urban areas, where people and jobs are clustered together, facilitating information exchange between workers and industries and the spread of tacit knowledge (Marshall, 1890). Tacit knowledge is difficult to transfer to other parties, requiring substantial resources to attach it to the place of production and the actors involved in its development through learning processes (Von Hippel, 1994). As a result, the increase in the urban population leads to substantial gains in firms' capacity for process and product innovation and R&D activities, driven by the effects of agglomeration on knowledge diffusion, particularly the presence of universities in the city and firms' investment in R&D (Chen et al., 2020). Thus, knowledge spillovers are a type of agglomeration externalities that contribute to firms' innovation dynamics. Research has shown that external knowledge plays a crucial role in firms' innovation processes, and knowledge spillovers can increase the productivity of related activities while reducing costs by providing access to inputs generated by other firms (Griliches, 2007). Zhang et al. (2014)'s study on the relationship between agglomeration economies and R&D investment in manufacturing industries found that both urbanization and localization economies have a significant impact on firms' R&D. The proximity of firms to one another is also essential for external effects (Audretsch and Feldman, 1996; Jaffe et al., 1993; Quatraro and Usai, 2017). Studies have shown a positive relationship between the knowledge produced by co-located firms and the productivity of innovation activities in the surrounding area. In Fang (2019)'s research, the focus was on the connection between agglomeration and innovation of less innovative firms located outside the agglomeration space, and more innovative ones located within the agglomeration. Results revealed that a one-mile radius with above-median employment concentration significantly encourages firm innovation. Moreover, innovative establishments within corresponding employment centers record an increase in their citation-weighted patent applications, while non-innovative establishments are less likely to survive in agglomerations.

Moreover, Jacob's externalities consider the composition of local knowledge, not just its stock. These externalities are associated with the variety of firms and industries in a particular area and emphasize the importance of knowledge variety for the creation of new knowledge. The relatedness of technological variety is essential to qualify local knowledge spillovers and their effects on

firm innovation. Related variety is a measure of coherence or specialization of technological activities, while unrelated variety is a measure of diversification. Studies analyzing the moderating effect of firms' location in an industrial district show a controversial result. While localization economies do not have a positive effect, it appears that urbanization economies play an important role in enhancing product innovation through the size and diversity of the urban environment. However, the non-significant effect of localization economies on innovation dynamics may be due to gender differences related to the segregation gap in agglomeration. Women may benefit less from agglomeration due to their less rich professional networks, limited access to credit, and domestic division of labor, among other factors. Based on this reasoning, we formulate the following hypothesis: Agglomerations that are predominantly female in term of employment contribute less to firms' innovation dynamics than agglomerations that are predominantly male in term of employment (Hypothesis 2.a). However, since women owners and managers may have more positive effects on firms' innovation dynamics than men managers and owners, we postulate that: The effect of both men and women managers agglomeration are beneficial for innovation as do men and women owners agglomeration (Hypothesis 2.b).

Furthermore, the exchange of knowledge between different locations is facilitated by the interaction of highly-qualified workers (Agrawal et al., 2006; Simonen and McCann, 2008). This labor mobility can lead to knowledge spillovers, which involve the sharing of valuable information between firms. Research has shown that firms located in industrial districts experience a significant reduction in the negative impact of workers leaving due to the beneficial effects of knowledge spillovers. Building on this idea, we propose the following hypothesis: Both men and women human capital agglomerations contribute equally to the firms' innovation dynamics (Hypothesis 2.c).

3 Gendered agglomeration and innovation framework

3.1 Overview

We propose a gendered agglomeration and innovation framework which enable us to study gendered agglomeration effects and their impact on firms' innovative activities. Especially, in the gendered agglomeration framework proposed, we consider three gender dimensions, such as, ownership, management, and employment. In the African context one may not be able to dissociate between the firm's ownership and management. The reason is that most of the firms are small business and managed by their owners. This claim is checked in our empirical analysis. For simplicity, our framework considers an owner-manager. The ownership/management dimension refers to the gender of the firm's owner/manager while employment is related to the gender of the firm's employees. Employment is akin of a human capital-augmented labor input and we split human capital into male and female. This enable us to also

analyze the effects of male-human capital versus female-human capital agglomeration on innovation. Labor is the only input for innovation and we assume that a firm probability of innovation depends positively on both the quantity and quality (human capital) of the labor hired. Besides, a firm also gains from the location choice she made. This indicates that there is a knowledge externality in the economy that enables the firm to benefit from spillovers effect that foster its human capital for innovation. We split this effect into male and female by accounting for the gender of owners/managers, employment or human capital-augmented labor: this is what we called gendered agglomeration. Thus, gendered agglomeration effects appear to matter significantly as the firm's probability of innovation will not only depend on its gender human capital intensity, but also on its location choice.

3.2 Gender productivity

Consider an economy with R locations. There is M firms in each location. Each firm is either run by a male or female owner/manager. The firm also disposed of L_m unit of male employment and L_f unit of female employment. We analyze gender both at the ownership/management and employment level.

A firm productivity Z_{ir}^g (with $g = \{m, f\}$) is analyzed as gender productivity and could be determined either at the ownership/management or employment level. Denote by $X = \{x_{i1}, x_{i2}, x_{i3}, \dots, x_{ij}\}$ the set of firm-specific characteristics that could possibly affects her productivity. For a firm i in location r , the gender productivity is given by:

$$Z_{ir}^g = g \exp \sum_i \alpha_{ir} x_{ij} \quad (1)$$

where g stands for the gender dimension. At the ownership/management level, this correspond to either male or female owner/manager. And at the employment level, it is either male or female employment. x_{ij} is the characteristic j for firm i , and α_{ir} measures the effect of the firm-specific characteristic x_{ij} on the gender productivity which we assume to vary from a location to another. The location effects will be highlighted more explicitly later. The intuition in equation (1) is such that a firm's productivity either from a ownership/management or an employment point of view is determined by the gender of the owner/manager or employees as well as many other parameters that are firm-specific. In our empirical analysis, several characteristics are considered, such as, the firm size, the firm's capacity utilisation, domestic and foreign ownership, competition, etc. Now that we know how the gender productivity is determined, we can now turn to our main focus which is the link between gendered agglomeration and firm's innovation.

3.3 The probability of innovation

Firms perform different types of innovations by conducting R&D, an uncertain activity, for it may fail to produce any innovations. For simplicity and clarity of exposition, we assume that a firm's benefit from innovation is function of her productivity which is equals to $(Z_{ir}^g)\eta$ with $\eta > 1$. Let $\exp(I_{ir})$ be the probability of innovation for firm i in location r . Thus, with probability $\exp(I_{ir})$, the firm will succeeds R&D and earn the benefit $(Z_{ir}^g)\eta$. She will get zero otherwise. Thus the expected benefit from innovation is:

$$\exp(I_{ir})(Z_{ir}^g)\eta.$$

However, the research will cost her $\exp(I_{ir})\eta+1$ whether she succeeds or not. Thus, her net benefit from research is :

$$\exp(I_{ir})(Z_{ir}^g)\eta - \exp(I_{ir})\eta+1.$$

As we will see later, the firm probability will depend on her intensity of human capital as well as her location. Choosing those two factors is equivalent to choosing her probability of innovation. Then, the firm will choose the probability that maximizes her net benefit, which implies that $\exp(I_{ir})$ must satisfy the first-order condition:

$$(Z_{ir}^g)\eta - (\eta + 1) \exp(I_{ir}) = 0.$$

The probability of innovation is then given by:

$$\exp(I_{ir}) = \varphi Z_{ir}^g. \quad (2)$$

where $\varphi = \frac{1}{\eta+1} \frac{1}{\eta}$ can be interpreted as the research sector productivity. Equation (2) says that a firm's probability of innovation depends on her productivity which is determined by the gender of her owner/manager or employees. In our empirical analysis, we consider several types of innovations, such as, product, process, marketing as well as aggregate innovation.

3.4 Gendered agglomeration's knowledge spillover

The link between innovation and gender productivity in equation (2) does not explicitly show the effect of gendered agglomeration as the parameter φ is the same across firms and locations. One way to highlight this effect is to allow the parameter φ to be firm-and- location-varying. To do so, we suppose that a firm's benefit from innovation is function of her productivity which is equals to $(Z_{ir}^g)\eta_g$ where $\eta_g > 1$ are now firm-and-location- varying and gendered. Now, the probability of innovation becomes:

$$\exp(l_{ic}) = \varphi_{ic}^g Z_{ic}^g, \quad (3)$$

where φ_{ic}^g accounts for the gendered agglomeration effect for firm i in location r which itself is given by:

$$\varphi_{ic}^g = \frac{\sum_i \varphi_i^g}{a_r}$$

where φ_i^g is a gender measure in firm i , a_r is the area of the location r . Our empirical analysis consider the gender measure both at the ownership/management and the employment level. Thus, equation (3) will enable us to analyze the effect of gendered agglomeration on the firm's probability of innovation.

3.5 Human capital

As discussed in the overview section, employment corresponds to human capital- augmented labor input, because R&D activities required skilled workers. Within a firm, we split labor into male and female. Suppose that each unit of labor has been trained with s years of schooling. Thus, for firm i in location r , the gendered human capital augmented labor is given by:

In this specification, $\psi(s)$ indicates the efficiency of a unit of labor with s years of schooling relative to one with no schooling, that is $\psi(0) = 0$. An additional year of schooling raises a worker's efficiency proportionally by $\psi'(s)$. L_{ic}^g denotes the gendered labor for firm i in location r , with $g = \{m, f\}$. In order to be able to analyze the effects of male human capital-intensive firms versus female human capital-intensive firms on innovation, we consider a gendered human capital measure as specified below:

$$\exp(l_{ic}) = h_{ic}^g Z_{ic}^g, \quad (4)$$

where h_{ic}^g denotes a gendered human capital agglomeration measure which is given by:

$$h_{ic}^g = \frac{\sum_i H_{ir}^g}{a_r}$$

In our empirical analysis, we define human capital as the intensity of skills, knowledge, or know-how embodied in workers within a firm. And we consider workers that completed high school as the firm's pool of human capital. Thus, for firm i in location r , the gender human capital measure H_{ir}^g is computed using the number of the firm's workers that have completed high school.

4 Empirical strategy

4.1 WBES-2016 Data

We conducted an empirical analysis to investigate how both gender and gendered agglomeration impacts firms' innovation dynamics in Africa. To accomplish this, we used the World Bank Enterprises Surveys (WBES) from 2016. The WBES is a survey conducted by the World Bank in collaboration with the European Bank for Reconstruction and Development, the European Investment Bank, and the European Union. This survey gathers data on various aspects of manufacturing and service firms, including innovative activities, R&D, gender, geographical location, etc.

Table 1: Variables related to innovations and R&D		
Variables	Designation	Definitions
Product innovation	InvProd	Over the last three years, has the establishment introduced new products/services? This variable is binary taking the value 1 if the establishment introduced new products/services and 0 otherwise
Process innovation	InvProc	Over the last three years has the establishment introduced new processes? This variable is binary taking the value 1 if the establishment introduced new process and 0 otherwise.
Marketing innovation	InvMkg1	Does the establishment currently communicate with clients and suppliers by e-mail? This is a binary variable taking the value 1 if the establishment communicates with clients and suppliers by e-mail and 0 otherwise.
Marketing innovation	InvMkg2	Does the establishment has its own website? This is a binary variable taking the value 1 if the establishment has its own website and 0 otherwise
R&D investment	RD	In the last fiscal year, did the establishment spend on R&D (excluding market research)? This is a binary variable taking the value 1 if the establishment invests in R&D and 0 otherwise
Aggregate innovation	Aggregate	An ordered multinomial variable varying between 0 and 4. This is the sum of the four innovation variables: InvProd, InvProc, InvMkg1, and InvMkg2. Higher values indicate more innovative activities (4=Presence of the four types of innovation, 0=No innovation)

Tables 1 and 2 provide descriptions of the key variables used in our analysis. Using the WBES-2016, we were able to classify a firm's innovative activities into

different categories, including research and development (RD), product innovation (InvProd), process innovation (InvProc), marketing innovations (InvMkg1 and InvMkg2), and aggregate innovation (Aggregate), as shown in Table 1. Additionally, our database provides insights into three gender related aspects: management (Manager), ownership (Owner1 and Owner2), and employment (Employment) (Panel A: Table 2). We use these aspects to generate gender- based agglomeration variables, which are presented in Panel B of Table 2. Lastly, Panel C of Table 2 displays variables related to human capital agglomeration.

Table 2: Gender and agglomerations variables	
Designation	Definitions
Panel A: Variables related to gender	
Manager	This is a binary variable taking the value 1 if the establishment is headed by a woman and 0 otherwise.
Owner1	This is a binary variable taking the value 1 if there is any woman among the establishment owners and 0 otherwise.
Owner2	This is a binary variable taking the value 1 if more than 50% of the establishment shares is held by women and 0 otherwise.
Employment	This is a binary variable taking the value 1 if the ratio women employment to the total employment is at least 5% and 0 otherwise
Panel B: Variables related to gendered agglomeration	
MenMaAgglo	Ratio number of firms run by a men manager to the area of the region.
WomenMaAgglo	Ratio number of firms run by a woman manager to the area of the region.
MenEmAgglo	Ratio number of men employment within a region to the area of the region
WomenEmAgglo	Ratio number of women employment within a region to the area of the region.
MenOwAgglo	Ratio number of firms with men owners to the area of the region.
WomenOwAgglo	Ratio number of firms with women owners to the area of the region
Panel C: Variables related to human capital agglomeration	
Men HcapAgglo	Ratio men human capital to the area of the region.
WomenHcapAgglo	Ratio women human capital to the area of the region.

4.1.1 Firms' distribution by gender in the WBES-2016

Table 21 displays the distribution of firms in WBES-2016 by both country and industry. The survey covers 3, 921 African firms located in nine countries:

Benin, Cameroon, Cote d'Ivoire, Egypt, Guinea, Lesotho, Mali, Togo, and Zimbabwe. The number of firms surveyed varies by country, with 150 in Benin, Guinea, Lesotho, and Togo, 361 in Cameroon and Cote d'Ivoire, 185 in Mali, 600 in Zimbabwe, and 1814 in Egypt (Table 21: Panel A). We selected this database because it is the most recent and encompasses a wide range of African countries from different regions across the continent. With the exception of Egypt (46.26%) and Zimbabwe (15.30%), none of the remaining countries accounts for more than 10% of our study sample. Of the firms surveyed, 1,987 (50.68%) are in the manufacturing industry and 1,934 (49.32%) are in services (Table 21: Panel B). Regarding innovation policies, it's expected that all the firms are relatively homogeneous. This can be justified by the fact that out of the total 3,921 firms, only 37 Egyptian firms have been granted direct subsidies. Consequently, over 99% of the sample did not receive any innovation support, resulting in a high degree of similarity among all the firms.

The WBES-2016 classifies firms according to gender based on three different factors: employment, management, and ownership. Table 3 provides data on the distribution of firms by gender in terms of men and women employment. Employment is more concentrated in the business center than in other locations. Across all regions, firms tend to employ more men than women. For instance, the Greater Cairo region in Egypt has the highest concentration of employment, with a total of 132,439 workers, of which 127,787 are men and 4,652 are women. In total, our database includes 449,095 men and 20,633 women employees.

Table 3: Regional distribution of employment by gender

Code	Regions	Men	Women	Total
BEN-1	Atlantique, Borgou, Mono, Ouémé (BEN)	1,816	191	2,007
BEN-2	Littoral (BEN)	9,475	493	9,968
CMR-1	Center (CMR)	4,583	389	4,972
CMR-2	Littoral (CMR)	6,720	488	7,208
CMR-3	West of Cameroon (CMR)	1,306	20	1,326
CIV-1	Abidjan (CIV)	15,493	384	15,877
CIV-2	Rest of Côte d'Ivoire (CIV)	3,297	177	3,474
EGY-1	Frontier (EGY)	1,409	118	1,527
EGY-2	Greater Cairo (EGY)	127,787	4,652	132,439
EGY-3	Middle and East Delta (EGY)	48,313	2,057	50,370
EGY-4	Northern Upper Egypt (EGY)	31,143	4,305	35,448
EGY-5	Southern Upper Egypt (EGY)	5,438	47	5,485
EGY-6	Suez Region (EGY)	26,593	13	26,606
EGY-7	West Delta (EGY)	57,072	662	57,734

GIN-1	Conakry (GIN)	5,069	93	5,162
LSO-1	Lesotho (LSO)	23,722	3,926	27,648
MLI-1	Bamako (MLI)	8,306	283	8,589
MLI-2	Mopti, Ségou, Sikasso (MLI)	2,332	8	2,340
TGO-1	Lomé (TGO)	7,889	251	8,140
TGO-2	Plateaux, Centrale, Kara (TGO)	212	82	294
ZWE-1	Bulawayo (ZWE)	8,095	600	8,695
ZWE-2	Harare (ZWE)	47,681	1,114	48,795
ZWE-3	Manicaland (ZWE)	1,664	177	1,841
ZWE-4	Midlands (ZWE)	3,680	103	3,783
Total		449,095	20,633	469,728

Moreover, Table 4 presents the regional distribution of firms by gender in terms of management and ownership. The concentration of firms' managers and owners is much higher in the business center than in other cities, especially for male managers and owners (MenMa, MenOw1, and MenOw2) compared to female managers and owners (WomenMa, WomenOw1, and WomenOw2). Out of 3,532 firms, a man is the manager of 3,143, while only 389 are headed by a woman. Of the 3,084 firms with at least one owner, all owners are men in 3,084 firms, while in 837 firms, there is at least one woman owner. Furthermore, 3,582 firms have mostly men owners, while in 339 firms, the owners are mostly women.

Table 4: Regional distribution of firms by gender

Code	MenMa	WomenMa	MenOw1	WomenOw1	MenOw2	WomenOw2
BEN-1	36	6	30	12	36	6
BEN-2	91	17	70	38	95	13
CMR-1	114	35	83	66	102	47
CMR-2	127	16	99	44	113	30
CMR-3	64	5	49	20	58	11
CIV-1	235	33	200	68	239	29
CIV-2	82	11	73	20	85	8
EGY-1	73	7	77	3	77	3
EGY-2	650	41	616	75	682	9
EGY-3	324	14	315	23	333	5
EGY-4	161	9	159	11	160	10
EGY-5	121	5	122	4	121	5
EGY-6	117	3	109	11	117	3
EGY-7	278	11	252	37	285	4
GIN-1	141	9	132	18	139	11
LSO-1	101	49	82	68	109	41
MLI-1	121	12	107	26	122	11
MLI-2	51	11	48	4	50	2

TGO-1	106	11	82	35	108	9
TGO-2	27	6	27	6	27	6
ZWE-1	140	26	94	72	141	25
ZWE-2	208	38	131	115	215	31
ZWE-3	78	13	63	28	82	9
ZWE-4	86	11	64	33	86	11
Total	3,532	389	3,084	837	3,582	339

4.1.2 R&D and innovations distribution in the WBES-2016

Figure (1) presents an overview of firms' innovation and R&D activities in the sample. Among the different types of innovations, marketing innovations was the most commonly introduced by firms, with 2,687 (InvMkg1) and 1,790 (InvMkg2) firms reporting having introduced it. This was followed by product innovation (835 firms) and process innovation (439 firms). Similarly, a significant number of firms do not engage in R&D (381 compared to 3,540), which explains the lower levels of innovation performance observed.

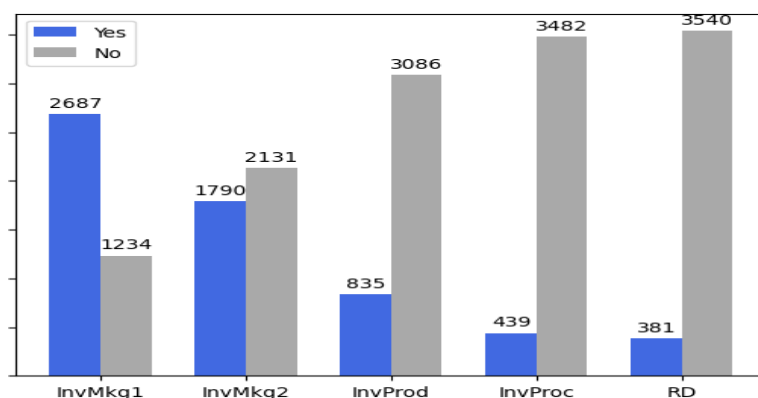


Figure 1: R&D and innovations

Table 5: R&D and innovations by gender

R&D and innovations	Gender	Men	Women
InvProd	Manager	743	92
	Owner1	578	257
	Owner2	740	95
	Employment	584	251
InvProc	Manager	402	37
	Owner1	314	125
	Owner2	395	44
	Employment	325	114
InvMkg1	Manager	2,436	251
	Owner1	2,059	628
	Owner2	2,494	193

InvMkg2	Employment	2,003	684
	Manager	1,662	128
	Owner1	1,412	378
	Owner2	1,707	83
RD	Employment	1,451	339
	Manager	351	30
	Owner1	280	101
	Owner2	360	21
	Employment	290	91

Table 5 provides descriptive statistics on firms' innovations and R&D by gender. Across all dimensions of gender considered, men were associated with greater levels of innovative activities. Firms with more than 50% of their shares held by men were more likely to conduct R&D (360 firms) and to introduce marketing innovations, with a higher number of marketing innovations introduced (2,494 firms). The distribution of aggregate innovation is presented in Tables 23 and 24. Higher values of aggregate innovation imply a greater overall level of innovation. When it comes to aggregate innovation, firms have predominantly introduced two types of innovations (37.34% of the total sample). More than 24% of the total sample (equivalent to 979 firms) have no innovation while 4.67% (183 firms) of the sample has introduced the four types of innovations (see Table 23). The distribution of aggregate innovation by gender shown in Table 24 reveals that firms have predominantly introduced two types of innovations, with a higher number of innovations reported in firms led by men. Specifically, 1,346 firms managed by men have introduced two types of innovations compared to only 118 firms managed by women. Similarly, 1,387 firms with more than 50% of the firm's shares held by men have introduced two types of innovations, while only 77 firms with more than 50% of the firm's shares held by women have done so. Finally, 1,172 firms with more male employees have introduced two types of innovations compared to 292 firms with more female employees.

4.2 Methodology

4.2.1 Econometric specifications

In order to determine how gendered agglomeration affects innovation dynamics, we used several econometric specifications. First, we start by evaluating the effects of gender on firms' innovative activities. It steps from the literature that gender-related variables might be endogenous (Jha and Sarangi, 2018). We used the Heckman two-step regression model with instrumental variable to mitigate the endogenous concerns. Thus, applying the natural logarithm to the equation (1) from the theoretical framework, we construct the first stage regression model as follows :

$$Gender = \alpha + \delta_i Respondent + \sum_j x_j + \epsilon_i \quad (5)$$

In equation (5), Gender represents each gender-related variables, such as, ownership, management, and employment. Respondent is our instrument variable indicating the gender of the main respondent of the WBES-2016 for the firm. The reason of using this as instrument is that the respondent is probably chosen by the owner/management. However, both R&D and innovation decisions do not come from the respondents. The x_j represent control variables (see Table 25). The estimation is performed using the maximum likelihood estimator. To deal with the selection bias, the inverse of Mills ratio (IMR) proposed by Heckman is calculated from equation (5) and introduced into the second step equation as an explanatory variable

$$Innovation = \alpha + \delta_i Gender + \sum_j x_j + IMR + \epsilon_i \quad (6)$$

We obtain this Heckman second step equation by applying the natural logarithm to the equation (2) from the theoretical framework. In equation (6), we used the variable Innovation to represent the different types of innovations (product, process, and marketing) as well as R&D investment. Those variables are dummy variables and we used a simple probit model. The variable R&D is used to evaluate how gender affect R&D investment decision-making. The same control variables are used in both the first and second stage of our regression. The variable IMR represents the inverse Mills ratio calculated from the equation (5). In order to deal with the selection bias, the Chi2 test is performed on the correlation coefficient of the error terms of equation (6). Thus, the rejection of the null hypothesis (p value < 0.05 if critical threshold at 5%) means that the two steps of the regression are effectively linked.

Second, we analyze the effect of gendered agglomeration on the firm's probability of innovation using equation (3) from the theoretical framework. The equation to be estimated is as follows:

$$Innovation = \alpha + \delta_i GendAgglo + \sum_j x_j + \epsilon_i \quad (7)$$

where GendAgglo denotes our gendered agglomeration variables: owners agglomeration, managers agglomeration, and employment agglomeration. The effects on innovation are expected to be positive and varying depending on the gender dimension considered. We also used equation (7) to determine the effect of gendered agglomeration on the firm's R&D decision-making.

4.2.2 Robustness checks

We run two main robustness checks. First, we analyse the effects of male-human capital agglomeration versus female-human capital agglomeration on firms' innovative activities. We evaluate the effects of gendered human capital agglomeration on product, process, and marketing innovation, and also determine the effects on the firm's R&D decision-making. For that purpose, we estimate the following equation:

$$Innovation = \alpha + \delta_i HumAgglo + \sum_j x_j + \epsilon_i \quad (8)$$

where HumAgglo denotes our gendered human capital agglomeration variables. Since human capital are crucial for innovation, we expected both male and female human capital agglomeration to positively affect innovation activities.

Second, we study how both gender and gendered agglomeration affects aggregate innovation. To do this, the dependant variable Innovation in each specification is replaced by the aggregate innovation (Aggregate), which is the sum of all four dummy variables as an aggregate measure of a firm's overall innovation. Since the dependent variable is now an ordinal variable ranging from 0 to 4, the ordered probit regression model is used. Our regressions include industry and country dummies, as well as many other control variables listed in table 25.

5 Results and discussions

The results of the gender effect on innovation are presented in Tables 6-10. Our analysis using the Heckman probit model with instrumental variable offers robust and credible findings that address the issue of endogeneity between gender and innovation, whenever it arises. In most of our estimations, the coefficient associated to the inverse of Mills ratio (IMR) is significant. This is the case for both marketing innovations (InvMkg1 and InvMkg2) and for R&D investment (only when the aspect of gender Owner2 is considered). The IMR is then introduced as an explanatory variable in the second stage of the Heckman probit estimation to address the selection bias between marketing innovations, R&D investment and the gender-related variables. We then access the effect of the gendered agglomeration on innovation by directly estimating a probit model. The resulting findings are presented in Tables 11 and 20. Our robustness analysis estimates an ordered probit model and shows the results in Tables 27 and 28. In all our estimations, we solve the heteroscedasticity problem by applying the robust command. The Pearson correlation matrix (see Table 29) reveals a very strong relationship between, the explained variables, the explained and explanatory variables, and a very weak correlation between the

explanatory variables. Finally, the variables used for the different estimations are not subject to multicollinearity or redundancy information problems.

5.1 Relationship between gender and innovation dynamics

The results for the gender effects on innovation dynamics reveal a complex pattern for the various gender-related variables used. For instance, female management has been shown to have a negative influence on a firm's probability to perform marketing innovations (see Table 6).

Table 6: Gender effect on innovation: Manager

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
Manager	0.064 (0.085)	0.017 (0.022)	-0.054 (0.099)	-0.009 (0.017)	-0.050 (0.113)	-0.008 (0.018)	-0.161** (0.080)	-0.050** (0.025)	-0.206** (0.083)	-0.065** (0.026)
IMR	-0.030 (0.220)	-0.008 (0.056)	-0.302 (0.250)	-0.053 (0.044)	-0.049 (0.275)	-0.008 (0.044)	0.706*** (0.217)	0.217*** (0.067)	0.638*** (0.216)	0.200*** (0.068)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.113		0.087		0.079		0.133		0.199	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Gender effect on innovation: Owner1

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
Owner1	0.078 (0.085)	0.020 (0.022)	0.052 (0.097)	0.009 (0.017)	-0.242** (0.123)	-0.038** (0.019)	-0.339*** (0.083)	-0.104*** (0.025)	-0.256*** (0.090)	-0.080*** (0.028)
IMR	0.070 (0.274)	0.018 (0.070)	-0.288 (0.322)	-0.050 (0.056)	0.152 (0.338)	0.024 (0.053)	1.117*** (0.281)	0.342*** (0.086)	0.665** (0.260)	0.208** (0.081)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.113		0.086		0.081		0.136		0.199	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1



Table 8: Gender effect on innovation: Owner2

VARIABLES	InvProd		InvProc		R		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
Owner2	0.199*** (0.059)	0.051*** (0.015)	0.094 (0.068)	0.016 (0.012)	0.038 (0.071)	0.006 (0.011)	0.129** (0.060)	0.040** (0.018)	0.145** (0.058)	0.045** (0.018)
IMR	0.494 (0.489)	0.126 (0.125)	-0.020 (0.541)	-0.004 (0.094)	1.167** (0.534)	0.184** (0.084)	2.227*** (0.497)	0.681*** (0.151)	2.053*** (0.464)	0.641*** (0.144)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.116		0.086		0.081		0.136		0.202	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Specifically, when a woman manager is in charge, the probability of communicating with clients and suppliers via email (InvMkg1) and having a

website (InvMkg2) is reduced. This finding is consistent with prior research by Mueller (2004), Reuvers et al. (2008) and Luksyte et al. (2018) which suggest that men tend to be more risk-averse than women, and there is a higher representation of male managers in general.

Similarly, having any woman among the firm's owners (Owner1) has a negative impact on the firm's probability to innovate in marketing and to invest in R&D (see Table 7). However, when the firm's ownership is highly represented by female owners, that is when there is more than 50% of women among the firm's owners (Owner2), this increases the firm's probability to perform product and marketing innovation (InvProd and InvMkg1) (see Table 8). These findings are related to those of Dezs'o and Ross (2012) and Chen et al. (2020) and could be attributed to the management role of women owners in certain firms. Another possible explanation is that women owners tend to, communicate more frequently, are more cooperative, and less self-centered than men (Eckel and Grossman, 1998; Wolfram et al., 2007; Lee et al., 2018). We also observed that female managers do not influence the firm's investment in R&D while female owners do. We corroborated these findings by considering a specific case in the African context where the manager holds ownership as well (see Table 9). The results confirm that the firm's R&D investment decisions are undertaken by the firm's ownership rather than its management. Moreover, when at least 5% of the firm's employees are women, this reduces the firms' probability to invest in R&D and to perform product and marketing innovations (see Table 10).

Table 9: Gender effect on innovation: Manager x Owner1

VARIABLES	InvProd		InvProd		RD		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
Owner1Ma	0.064 (0.105)	0.0165 (0.0269)	-0.039 (0.118)	-0.00672 (0.0206)	-0.313** (0.154)	-0.0494** (0.0243)	-0.201** (0.103)	-0.0620** (0.0315)	-0.390*** (0.118)	-0.122*** (0.0370)
IMR	0.163 (0.211)	0.0418 (0.0541)	-0.064 (0.236)	-0.0111 (0.0412)	0.086 (0.273)	0.0135 (0.0431)	0.331 (0.219)	0.102 (0.0672)	0.293 (0.218)	0.0916 (0.0683)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.113		0.086		0.081		0.131		0.199	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 10: Gender effect on innovation: Employment

VARIABLES	InvProd		InvProd		R		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
Employment	-0.114* (0.066)	-0.029* (0.017)	-0.122 (0.080)	-0.020 (0.013)	-0.133* (0.081)	-0.021* (0.013)	-0.234*** (0.060)	-0.070*** (0.018)	-0.265*** (0.059)	-0.083*** (0.018)
IMR	-0.944 (0.578)	-0.239 (0.146)	0.089 (0.705)	0.015 (0.116)	-0.917 (0.775)	-0.145 (0.123)	-3.812*** (0.600)	-1.132*** (0.175)	-1.969*** (0.619)	-0.615*** (0.192)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.114		0.072		0.083		0.155		0.204	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Overall, our findings contrast with those of Na and Shin (2019), who analyzed the impact of gender on firms' innovative activities in emerging economies. Their study revealed, a positive relationship between female ownership and the various innovation measures considered; a positive relationship between female top management and marketing innovation; and no significant effect was found on innovation when taking into account the predominance of women in the firm's workforce. An explanation for the observed adverse impacts, when considering all aspects of gender (ownership, management, and employment), could be attributed to the underrepresentation of women in various roles such as owners, managers, and employees within African firms.

5.2 Gendered agglomeration effects on innovation dynamics

Regarding the gendered agglomeration effects on innovation dynamics, our estimations reveals that the agglomeration of men as managers increases the firm's probability to perform product, process, and marketing innovations (see Table 11). Similarly, even if no effect was found on process innovation, the agglomeration of women managers also affects positively the firm's probability to perform product and marketing innovations (see Table 12). In all cases, the marginal effects are greater for women agglomeration than men. This implies that a one percent increase in women managers agglomeration results in a more pronounced probability of innovation, whereas an equivalent increase in the agglomeration of men managers leads to a comparatively lesser impact.

Table 11: Men manager agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
MenMaAgglo	0.650*** (0.207)	0.166*** (0.053)	0.477** (0.226)	0.083** (0.039)	0.052 (0.224)	0.008 (0.035)	0.646*** (0.187)	0.198*** (0.057)	0.865*** (0.201)	0.270*** (0.062)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.116		0.087		0.079		0.133		0.201	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12: Women manager agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
WomenMaAgglo	2.755** (1.167)	0.705** (0.298)	1.702 (1.252)	0.297 (0.218)	-0.362 (1.260)	-0.057 (0.199)	2.568** (1.082)	0.791** (0.331)	4.206*** (1.147)	1.316*** (0.357)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.114		0.086		0.079		0.132		0.199	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Similar outcomes were found considering the agglomeration of owners. In particular, the agglomeration of both men and women as owners increases the firm's probability to perform, process, and marketing innovations. Men owners agglomeration also promotes product innovation, with each instance of this effect being more potent for women than men owners agglomeration (see Tables 13 and 14). This strong beneficial effect for women agglomeration may be attributed to the fact that women owner-entrepreneurs benefit more from agglomeration than men due to their limited professional networks and restricted access to credit (Rosenthal and Strange, 2012).

Table 13: Men owner agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkt1		InvMkt2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
MenOwAgglo	0.890*** (0.271)	0.227*** (0.069)	0.698** (0.296)	0.121** (0.051)	0.102 (0.291)	0.016 (0.046)	0.883*** (0.242)	0.271*** (0.074)	1.161*** (0.263)	0.363*** (0.081)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.116		0.087		0.079		0.134		0.201	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 14: Women owner agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margina	Coef.	Margina	Coef.	Margina	Coef.	Margina	Coef.	Margina
WomanOwAgglo	1.197** (0.484)	0.306** (0.124)	0.847 (0.520)	0.115 (0.090)	-0.116 (0.555)	-0.018 (0.085)	1.165** (0.457)	0.358** (0.140)	1.772*** (0.471)	0.554*** (0.147)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.115		0.086		0.079		0.151		0.200	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 15: Men Owner-Manager agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margina	Coef.	Margina	Coef.	Margina	Coef.	Margina	Coef.	Margina
MenOwMaAgglo	0.628** (0.289)	0.161** (0.074)	0.677* (0.375)	0.118* (0.065)	-0.022 (0.504)	-0.005 (0.048)	0.912** (0.255)	0.198** (0.078)	0.889*** (0.278)	0.279*** (0.087)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.114		0.087		0.079		0.151		0.199	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 16: Women Owner-Manager agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margina	Coef.	Margina	Coef.	Margina	Coef.	Margina	Coef.	Margina
WomenOwMaAgglo	3.924 (2.658)	1.005 (0.675)	3.687 (3.085)	0.845 (0.554)	-1.570 (2.908)	-0.245 (0.480)	2.775 (2.545)	0.856 (0.782)	7.262*** (2.650)	2.276*** (0.828)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.115		0.086		0.079		0.151		0.198	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 17: Men employment agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margina	Coef.	Margina	Coef.	Margina	Coef.	Margina	Coef.	Margina
MenEmAgglo	0.008*** (0.002)	0.002*** (0.000)	0.008*** (0.002)	0.001*** (0.000)	0.002 (0.002)	0.000 (0.000)	0.008*** (0.002)	0.002*** (0.000)	0.008*** (0.002)	0.002*** (0.000)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.117		0.089		0.079		0.155		0.199	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Tables 15 and 16 show the joint effect of men owner-manager agglomeration and women owner-manager agglomeration respectively. The results indicate

that the agglomeration of both men and women viewed jointly in term of management and ownership influence positively the firm's probability to perform marketing innovation (InvMkg2). Men owner-manager agglomeration also contributes positively to the firm's probability to perform product and process innovations. Moreover, as shown in Tables 17 and 18), the agglomeration of both men and women as employees influence positively the firm's probability to perform product, and marketing innovations. Men employees agglomeration also favors the firm's probability to perform process innovation. Still, all the marginal effects are stronger for women than man agglomeration.

Table 18: Women employment agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
WomanEmpAgglo	0.100** (0.043)	0.026** (0.011)	0.079 (0.048)	0.014 (0.008)	-0.009 (0.045)	-0.001 (0.007)	0.087** (0.038)	0.027** (0.012)	0.142*** (0.041)	0.044*** (0.013)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.115		0.087		0.079		0.132		0.199	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 19: Men human capital agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
MenHcapAgglo	0.005*** (0.001)	0.001*** (0.000)	0.005** (0.002)	0.001** (0.000)	0.001 (0.002)	0.000 (0.000)	0.005*** (0.002)	0.001*** (0.001)	0.005*** (0.002)	0.002*** (0.001)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.115		0.088		0.079		0.132		0.199	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 20: Women human capital agglomeration effect on innovation

VARIABLES	InvProd		InvProc		RD		InvMkg1		InvMkg2	
	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins	Coef.	Margins
WomanHcapAgglo	0.005*** (0.002)	0.001*** (0.001)	0.007** (0.005)	0.001** (0.000)	0.005* (0.005)	0.001* (0.000)	0.005** (0.005)	0.002** (0.001)	0.004 (0.002)	0.001 (0.001)
Control variables	Yes		Yes		Yes		Yes		Yes	
Industry dummy	Yes		Yes		Yes		Yes		Yes	
Country dummy	Yes		Yes		Yes		Yes		Yes	
Observations	3,921		3,921		3,921		3,921		3,921	
Pseudo-R ²	0.115		0.088		0.081		0.132		0.197	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Regarding the effect of human capital agglomeration on innovation, the agglomeration of both men and women human capital contributes to increasing the firm's probability to perform product, process, and marketing innovations. Women human capital agglomeration also influence positively the firm's R&D investment decision (see Tables 19 and 20). These findings can be explained by the fact that women possess unique domestic labor abilities that enable them to foster team creativity, facilitate information sharing, and mitigate status conflicts within groups (Eckel and Grossman, 1998; Wolfram et al., 2007; Rosenthal and Strange, 2012; Lee et al., 2018).

5.3 Robustness analysis

Our robustness analysis consists to evaluate the relationship between, gender, gendered agglomeration and innovation, while considering the diversity present in the firm's innovative activities. Table 27 shows the ordered probit regression results for the gender effect on innovation. It appears that, having a woman as manager, having any women among the firm's owners, and having a predominantly female workforce decrease the firm's probability of innovation. However, when there is more than 50% of women among the firm's owners, this increases the firm's probability of innovation. The ordered probit regression results for the gendered agglomeration effect on innovation are presented in Table 28. The findings confirm a positive relationship between gendered agglomeration (management, ownership and employment) and innovation. Human capital agglomeration (male and female) also impacts positively the firm's probability to innovate. Overall, it is important to highlight that the effects of both gender and gendered agglomeration on innovation stay negative for the first and second type of innovations introduced by the firm. However, this effect turns positive starting from the third type of innovations and becomes even stronger for the fourth type. Consequently, the positive impact of both gender and gendered agglomeration innovation is influenced by the diversity present in the firm's innovative activities. Another important findings to highlight is that human capital agglomeration effects on innovation are equal for both male and female human capital agglomeration. This confirms that only the knowledge matters for innovation without making any difference between the gender of who carries this knowledge. In summary, Hypothesis 1.a and 1.c are confirmed. That is, the proportion of the firm's women employees as well as the proportion of women among the firm's owners influence her innovative activities. In Africa women are underrepresented in the firm's ownership, management and employment. Having a predominantly female management, ownership and employment should enhance innovation dynamics in Africa. Similarly, Hypothesis 2.b, and 2.c are supported, confirming that all kind of agglomeration contribute equally to innovation dynamics. Therefore, in Africa, both women and men agglomeration are important and contribute to firms' innovative activities. Regarding human

capital, only the individual skills matter for innovation, and firms do not differentiate between men and women based on their qualifications.

6 Conclusion and economic policies

Our study investigates how both gender and gendered agglomeration influence innovation dynamics in Africa. We analyze gender in different point of view, such as, ownership, management, and employment; and consider various types of innovations including, product, process, marketing, aggregate innovation, and R&D. Our econometric specification employs a two-stage Heckman probit models with instrumental variable to address both endogeneity and selection biases between gender-related variables and innovation. Moreover, an ordered probit model were used for robustness analysis, taking into account the diversity present in the firm's innovative activities. Using data on 3,921 firms from nine countries, Benin, Cameroon, Cote d'Ivoire, Egypt, Guinea, Lesotho, Mali, Togo, and Zimbabwe, we document strong evidences for both gender and gendered agglomeration effects on innovation dynamics. First, our findings reveal that the beneficial impact of both gender and gendered agglomeration on innovation are contingent upon the diversity present in the firm's innovative activities. Our robustness analysis confirms this result as it highlights a negative effect for both gender and gendered agglomeration on innovation for the first and second type of innovations introduced by the firm. However, this effect turns positive starting from the third type of innovations and becomes even stronger for the fourth type. Second, both male and female agglomeration influence positively innovation dynamics, with a greater effects for women agglomeration than men. More specifically, the agglomeration of both men and women as managers increase the firm's probability to perform product and marketing innovations; the agglomeration of both men and women as owners increase the firm's probability to perform, process, and marketing innovations; and the agglomeration of both men and women as employees influence positively the firm's probability to perform product, and marketing innovations. Men owners agglomeration also promotes product innovation, while the agglomeration of both men employees and managers favors the firm's probability to perform process innovation. Third, our findings regarding human capital reveal that the nature of the agglomeration does not matter for innovation. Having equal effects for both male and female human capital agglomeration, our study confirms that only the knowledge matters for innovation without making any difference between the gender of who carries this knowledge. Fourth, the decisions regarding R&D expenditures are made by the firm's ownership rather than its management. We observed that women managers have no significant effect on the firm's R&D investment decisions while women owners do. We considered instances where the manager holds ownership as well and the results are robust.

Our study could serve as a valuable resource for providing various policies recommendations, including, innovation-related policies, gender, inequality and inclusion, women engagement in economic activities, etc. Women are underrepresented among both the firm's ownership and management. African government should then promote gender inclusion by encouraging women entrepreneurship. The employment role within the firm also lacks adequate representation of women. Then, African government should ensure access to employment for both women and men without discrimination. Moreover, a large amount of firms does not conduct R&D and consequently perform less innovations. African government should then establish and promote a system to support and assist firms' innovative activities, including both direct subsidies and R&D tax credit. The latter is widely used in developed countries, and most studies conclude that firms increase their R&D expenditures in response to R&D tax credits. For future research, it would be interesting to examine how R&D incentives will impact firms' innovative activities in the African context, while considering the gender diversity.

References

- Agrawal, A., Cockburn, I., and McHale, J. (2006). Gone but not forgotten: knowledge flows, labor mobility, and enduring social relationships. *Journal of Economic Geography*, 6(5):571–591.
- An, Z., Huang, R.-J., Zhang, R., Tie, X., Li, G., Cao, J., Zhou, W., Shi, Z., Han, Y., Gu, Z., et al. (2019). Severe haze in northern china: A synergy of anthropogenic emissions and atmospheric processes. *Proceedings of the National Academy of Sciences*, 116(18):8657–8666.
- Andersson, K., Hussénius, A., and Gustafsson, C. (2009). Gender theory as a tool for analyzing science teaching. *Teaching and Teacher Education*, 25(2):336–343.
- Antonelli, C. and Colombelli, A. (2017). The locus of knowledge externalities and the cost of knowledge. *Regional Studies*, 51(8):1151–1164.
- Antonelli, C., Patrucco, P. P., and Quatraro, F. (2011). Productivity growth and pecuniary knowledge externalities: an empirical analysis of agglomeration economies in european regions. *Economic Geography*, 87(1):23–50.
- Audretsch, D. B. and Feldman, M. P. (1996). R&d spillovers and the geography of innovation and production. *The American economic review*, 86(3):630–640.
- Blake, M. K. and Hanson, S. (2005). Rethinking innovation: context and gender. *Environment and planning A*, 37(4):681–701.
- Che, Y. and Zhang, L. (2018). Human capital, technology adoption and firm performance: Impacts of china's higher education expansion in the late 1990s. *The Economic Journal*, 128(614):2282–2320.
- Chen, Q., Wang, C.-H., and Huang, S.-Z. (2020). Effects of organizational innovation and technological innovation capabilities on firm performance: evidence from firms in china's pearl river delta. *Asia Pacific Business Review*, 26(1):72–96.
- Deutsch, F. M. (2007). Undoing gender. *Gender & society*, 21(1):106–127.
- Dezső, C. L. and Ross, D. G. (2012). Does female representation in top management improve firm performance? a panel data investigation. *Strategic management journal*, 33(9):1072–1089.
- Eckel, C. C. and Grossman, P. J. (1998). Are women less selfish than men?: Evidence from dictator experiments. *The economic journal*, 108(448):726–735.
- Fang, L. (2019). Manufacturing clusters and firm innovation. *Economic Development Quarterly*, 33(1):6–18.
- Feldman, M. P. (1994). Knowledge complementarity and innovation. *Small business economics*, 6(5):363–372.
- Gallego, J. M. and Gutiérrez Urdaneta, L. H. (2018). An integrated analysis of the impact of gender diversity on innovation and productivity in manufacturing firms: Prepared for the institutions for development sector. Technical report, IDB Working Paper Series.

- Glaeser, E. L., Kallal, H. D., Scheinkman, J. A., and Shleifer, A. (1992). Growth in cities. *Journal of political economy*, 100(6):1126–1152.
- Griliches, Z. (2007). 13. Patent Statistics as Economic Indicators: A Survey. University of Chicago Press.
- Grinza, E. and Quatraro, F. (2019). Workers' replacements and firms' innovation dynamics: New evidence from Italian matched longitudinal data. *Research Policy*, 48(9):103804.
- Jaffe, A. B., Trajtenberg, M., and Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *the Quarterly journal of Economics*, 108(3):577–598.
- Jha, C. K. and Sarangi, S. (2018). Women and corruption: What positions must they hold to make a difference? *Journal of Economic Behavior & Organization*, 151:219–233.
- Kekezi, O. and Klaesson, J. (2020). Agglomeration and innovation of knowledge intensive business services. *Industry and Innovation*, 27(5):538–561.
- Kristinsson, K., Candi, M., and Sæmundsson, R. J. (2016). The relationship between founder team diversity and innovation performance: The moderating role of causation logic. *Long Range Planning*, 49(4):464–476.
- Lee, K., Szapiro, M., and Mao, Z. (2018). From global value chains (gvc) to innovation systems for local value chains and knowledge creation. *The European Journal of Development Research*, 30(3):424–441.
- Lindberg, M. (2012). A striking pattern: Co-construction of innovation, men and masculinity in Sweden's innovation policy.
- Lindberg, M. (2014). From exclusion to inclusion in public innovation support? innovative practices in bottom-up networks. *Scandinavian Journal of Public Administration*, 18(4):91–107.
- Lindberg, M., Forsberg, L., and Karlberg, H. (2015). Gendered social innovation—a theoretical lens for analysing structural transformation in organisations and society. *International Journal of Social Entrepreneurship and Innovation*, 3(6):472–483.
- Luksyte, A., Unsworth, K. L., and Avery, D. R. (2018). Innovative work behavior and sex-based stereotypes: Examining sex differences in perceptions and evaluations of innovative work behavior. *Journal of Organizational Behavior*, 39(3):292–305.
- Marshall, A. (1890). *Principles of economics* Macmillan. London (8th ed. Published in 1920).
- Mueller, S. L. (2004). Gender gaps in potential for entrepreneurship across countries and cultures. *Journal of developmental entrepreneurship*, 9(3):199.
- Na, K. and Shin, K. (2019). The gender effect on a firm's innovative activities in the emerging economies. *Sustainability*, 11(7):1992.
- Nahlander, J. (2010). Where are all the female innovators?: Nurses as innovators in a public sector innovation project. *Journal of technology management & innovation*, 5(1):13–29.

- Nyberg, A.-C. (2009). Making ideas matter: gender, technology and women's invention. PhD thesis, Luleå tekniska universitet.
- Pettersson, K. (2007). Men and male as the norm?: a gender perspective on innovation policies in Denmark, Finland and Sweden. Nordregio.
- Psacharopoulos, G. and Patrinos, H. A. (2004). Returns to investment in education: a further update. *Education economics*, 12(2):111-134.
- Quatraro, F. and Usai, S. (2017). Knowledge flows, externalities and innovation networks.
- Ranga, M. and Etzkowitz, H. (2010). Athena in the world of techne: The gender dimension of technology, innovation and entrepreneurship. *Journal of technology management & innovation*, 5(1):1-12.
- Rees, T. (2000). The learning region? integrating gender equality into regional economic development. *Policy & Politics*, 28(2):179-191.
- Reuvers, M., Van Engen, M. L., Vinkenburg, C. J., and Wilson-Evered, E. (2008). Trans-formational leadership and innovative work behaviour: Exploring the relevance of gender differences. *Creativity and Innovation Management*, 17(3):227-244.
- Rosenthal, S. S. and Strange, W. C. (2012). Female entrepreneurship, agglomeration, and a new spatial mismatch. *Review of Economics and Statistics*, 94(3):764-788.
- Ruiz-Jiménez, J. M., Fuentes-Fuentes, M. d. M., and Ruiz-Arroyo, M. (2016). Knowledge combination capability and innovation: The effects of gender diversity on top management teams in technology-based firms. *Journal of business ethics*, 135(3):503-515.
- Simonen, J. and McCann, P. (2008). Firm innovation: The influence of R&D cooperation and the geography of human capital inputs. *Journal of Urban Economics*, 64(1):146-154.
- Squires, J. (2005). Is mainstreaming transformative? theorizing mainstreaming in the context of diversity and deliberation. *Social politics: international studies in gender, state & society*, 12(3):366-388.
- Torchia, M., Calabro, A., Gabaldon, P., and Kanadli, S. B. (2018). Women directors contribution to organizational innovation: A behavioral approach. *Scandinavian Journal of Management*, 34(2):215-224.
- Von Hippel, E. (1994). "sticky information" and the locus of problem solving: implications for innovation. *Management science*, 40(4):429-439.
- Walby, S. (2005). Gender mainstreaming: Productive tensions in theory and practice. *Social Politics: International Studies in Gender, State & Society*, 12(3):321-343.
- Wolfram, H.-J., Mohr, G., and Schyns, B. (2007). Professional respect for female and male leaders: influential gender-relevant factors. *Women in Management Review*.
- Zhang, P., He, C., and Sun, Y. (2014). Agglomeration economies and firm R&D efforts: an analysis of China's electronics and telecommunications industries. *The Annals of Regional Science*, 53(3):671-701

Innovations and Firm Performance in Informal Manufacturing Enterprises: Field-based Evidence from India

Chandra Shekar K

kerala development and innovation strategic council

Joseph K J

Gulati Institute of Finance and Taxation

Abstract

The informal sector contributes significantly to output, employment, investments, exports and innovations in many developing countries. India, is a vivid example in this regard. The ability of informal manufacturing enterprises to implement and develop innovations is becoming increasingly important for sustainable growth and competitiveness. The goal of this paper is to examine the impact of product, process, and marketing innovations on firm performance. Based on an empirical analysis of 300 informal manufacturing firms in NCT- Delhi, the findings of the paper reveal that innovative firms exhibit higher productivity growth and sales growth underscoring the significance of the local market for informal manufacturing enterprises. These firms primarily cater to the local market in their vicinity and surrounding areas. However, firms exporting have improved the sales growth and productivity growth only via introducing marketing innovation

Key Words: Informal sector, Product innovation, Process innovation, Marketing innovation, firm performance, Primary survey

1. Introduction

Most of the emerging economies, including India, have a large informal sector, primarily because of its significant contribution to employment, GDP and economic development (Hart, 2006; Sengupta et al., 2009). The informal¹ enterprises are called so because they are not registered business units in the books of government and by that virtue they do not come directly under any Governmental regulations. Needless to mention, the overall economic development and welfare of the vast majority of the Indian workforce are crucially dependent upon the economic viability and sustainability of informal enterprises. In the current context of globalization wherein these units are exposed to heightened competition, ability to survive in the market depends on their innovation and competitiveness building.

However, Innovation in the informal sector typically takes place at the local level and tends to be new to the individual business or local context only. These innovations in informal sector enterprise emerges in response to day to day challenges and niche demand, using mainly resources found in the local area. These innovations are “grounded in developing local capabilities to produce a diverse range of goods and services which meet local needs” (Hoffecker, 2018). Therefore, these local market innovations may not fit mainstream understandings of innovation that tend to emphasise radical (often technological) change (Cozzens and Sutz 2014; Kraemer-Mbula et al. 2019), and, as a result, may not be considered as innovation in other parts of the world.

It is widely recognized that innovation plays a crucial role in enhancing firm productivity (Mairesse and Mohnen, 2010; Hall, 2011). These papers analyze various studies that investigate the connection between innovation activities and firm productivity using an expanded version of the model initially proposed by Crepon et al. (1998). However, the empirical evidence examining the impact of innovations in informal sector firm performance, remains scant and anecdotal (Shekar, K. C., & Paily, G., 2019). Therefore, this paper analyses the role of innovation in informal manufacturing enterprises, particularly in developing countries like India, and how does it affect their growth and competitiveness. Following this, the paper is aimed at assessing the impact of product, process and marketing innovation on firm performance based on a sample of Indian informal manufacturing enterprises. The impact of innovation on the growth of productivity, sales and profit is estimated by using probit model. Also, we argue that, as an informal firm targeting the local market improves their firm performance through exports via marketing innovations.

2. Related Literature

2.1 Defining Innovation in the context of informal sector

The most recent studies (de Beer et al., 2013; Daniels, 2010; Heeks et al., 2014; Ustyuzhantseva, 2015; Shekar, K. C., & Joseph, K. J., 2022) of innovation in developing countries adopt the recent OECD definition of innovation (OECD, 2005: 46): “An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations”. The existing literature suggest several innovation definitions. Innovation is also better understood from the point of view of developing countries as the process by which firms learn and introduce the design and manufacture of products and services which are new to them, regardless of whether they are new to their rivals (Mytelka, 2000).

2.2 Innovation and Firm performance

Innovation has played a crucial role in building international competitiveness of firms. Its contribution to efficiency, growth, and social change, in particular the longevity of many manufacturing enterprises has also been acknowledged in the literature (Dougherty, 1992; Druker 1993). Innovation has a significant impact on the firm performance by adopting an improved market position which confers a competitive advantage (Shekar, K.C., 2021; Joseph et al., 2021). The ability of informal manufacturing enterprises to implement and develop innovations is becoming increasingly significant for sustainable growth and competitiveness. Most importantly, innovation in the informal sector is essential to ensure cost efficiency, profitability as well as the distribution and production of new products or processes which meet the niche/local market demands (Kraemer and Wunsch, 2016). According to the International Labour Organisation (ILO, 2002), innovativeness and innovation motivate the informal sector to act as an incubator for business potential and a basis for the transition to the formal economy.

Several studies which focused on the relationship between innovation and firm performance provide a positive assessment of a higher innovation force, which leads to an increase in firm performance (Damanpour et al., 1989). However, these studies are generally conceptual in nature and / or focus only on one type of innovation rather than looking at the different types of innovations. Process and product innovations are the most frequently examined types of innovation. Studies by Baer and Frese (2003) and Olson and Schwab (2000) focus only on process innovations, while studies by Subramanian and Nilakanta (1996) and Atuagene-Gima (1996) report on product innovations. Much of this research focuses more or less on a positive association between innovation and firm performance, but some studies also suggest a negative or no association (Capon et al., 1990).

As Miller (2001) noted, most firms seek technological innovation to gain a competitive advantage in their respective market. Therefore, firms must be supported by marketing methods to achieve competitive gain. In general, researchers overlook “marketing innovations” that are equally important to the firm performance (Shekar, K. C., & Joseph, K. J., 2022). Relatively very few innovation literatures advocate or non-technological innovations. However, it is evident that firm with more marketing methods and organizational innovations achieve more efficient than their counter parts (Heeks, et al., 2014; Joseph et al., 2021).

The comparative studies on the impact of “product innovation” and “process innovations” on firm performance have pointed out that “product innovations” are relatively showing higher positive association with firm performance than “process innovation” (Walker, 2004). Gopalakrishnan (2000) broadened the subject and pointed out that the speed and the size of innovation are also relevant characteristics of innovation strength, even though both of the types of innovations have a positive effect on firm performance.

Similarly, Lin and Chen (2007) have shown the relationship between different types of innovation and firm sales and they argued that “organizational and marketing innovations”, rather than “technological innovation”, appeared to be the main driver of total sales. On the other hand, John and Davies (2000) ensured that marketing innovations increase sales by increasing the consumption of products and bringing additional benefits to companies. Moreover, in a recent empirical study of UK firms, Oke (2007) showed that different types of innovation are positively linked to firm performance.

In addition to innovative outcomes, several other factors can also influence firm performance. Stochastic theory of Gibrat of law relates the size distribution to the firm performance and states that firm size does not influence the growth of the firm. The growing empirical literature, however, shows the negative correlation between firm size and productivity (Bigsten and Gebreeyesus 2007; Dunne and Hughes 1994; Evans 1987). The passive learning model of Jovanovic (1982) expect that firm age and performance are negatively related in the firm's theory of a life cycle. Also, the studies based on firm level data have found that exporting firms tend to have higher productivity than non-exporting firms (Bernard and Jensen, 1999; Wagner, 2007).

3. Data

There is a lack of secondary sources of information on innovations and firm level data on informal sector enterprises in India, which is the primary focus of this study. Therefore, this study has conducted a field survey using structured questionnaire in NCT-Delhi² during August-December, 2018. The survey's overarching goal was to gather information on the type of innovations that informal manufacturing enterprises use and adapt to meet the consumers

changing needs and demands. Therefore, information has been gathered on several input and output innovation measurements. For methodological purposes, the study used multi stage stratified random sampling. After randomly selecting four industrial regions in NCT-Delhi and canvassing each selected zone, the study was able to identify informal manufacturing enterprises. A sample of 300 informal manufacturing enterprises was randomly selected using the information collected from the business directories of each selected region. Face-to-face interviews were then conducted using a structured questionnaire. The sample data captures widespread innovation activities in informal manufacturing enterprises, comprising of product, process and marketing innovations.

4. Variables and the Method

Firm performance is represented by mainly two variables, namely, (1) normalised sales growth which is a derived variable in the survey data measuring the change in sales reported in the current fiscal year from a previous period, and (2) normalised productivity growth which is derived from labour productivity growth. Considering data limitations, we use relative sales growth and productivity growth from the last three years as the indicators of firm performance. One of the reasons to convert the absolute growth to a relative is that the self-reported sales at present and three years back is not deflated by an appropriate price index, and therefore the growth rates are most likely inflated. In order to convert the absolute growth to relative growth, it is converted on a scale of 0 to 1 using the following equations below

$$\text{Normalised Sales Growth (NSG)} = \frac{\text{act salesgrowth} - \min \text{salesgrowth}}{\max \text{salesgrowth} - \min \text{salesgrowth}}$$

$$\text{Normalised Productivity Growth (NPG)} = \frac{\text{act prod\_growth} - \min \text{prod\_growth}}{\max \text{prod\_growth} - \min \text{prod\_growth}}$$

After converting them into a uniform scale ranging from 0 to 1, Tobit model has been used to evaluate the impact of innovations on annual sales growth and productivity growth.

Further to check robustness of results, we also examine the impact of innovations on change in turnover in last three years, which is measured qualitatively based on the revealed experiences of the firm's owner on whether they had experienced increase, decrease or no change in turnover in last three years. This relationship between innovation and change in turnover is modelled as multinomial logit model with three choices (1, 0, -1) representing increase, no change and decrease, respectively. We also estimate the probability of increase the growth of informal firms through introduction of innovations, with firms which experienced increase in turnover as the base category.

The key independent variables are innovation activities of firms during the last three years' period i.e., 2015, 2016 and 2017. The designed questionnaire specifically asks enterprises if they will add or make improvements to a new product, process and marketing method. The weighted quantities of all operations that represented each category of innovation were also calculated. In other words, an enterprise who needed to perform process or/and product or/and new marketing innovation activity were also considered. The innovation results are based on the enterprises' evaluation of innovation output at firm level with particular emphasis on incremental innovation. Enterprises are asked about enhanced processes or products which have been introduced whether they are new to the market or enterprise. The innovations which are new to the firm itself are also considered and not necessarily new to the market.

The first binary variable takes a value of one if a firm has produced at least one product only innovation and zero if it has produced no innovation within the three years.

$$|prod\_invni| = \begin{cases} 1, & prod\_invni > 0 \\ 0, & prod\_invni = 0 \end{cases}$$

Likewise, there is binary variable that relate to process and marketing innovation.

Innovation and firm performance is postulated to act as a function of firm-specific characteristics. Hence, firm age, exporting status, area and industrial activity are considered as controls in the analysis.

Age of firm: This is the natural logarithm of the years since the enterprise began operations in the region. In the other side, newly formed businesses and thus newer enterprises should prove to be more innovative, since, by theory, they prefer to introduce their new innovations before setting up their enterprise. Experienced firms, on the other hand appears to have more expertise acquired and other forms of capitalization.

Exporting: Economic theory and empirical results from studies relating formal sector firms suggests that firms with exposure to non-local markets via exporting are more likely to innovate and sustain in the competitive market (Braunerhjelm, 1996). Even through Developing economies predominantly compete in exports market through cost-effective measures it would be important to examine that informal sector innovation has something to do with exporting to non-local market.

Innovation and Firm performance equations:

$$Npg/nsg/change\_turnover = \beta_0 + \beta_1 Product\ innovation + \beta_2 firm\ age + \beta_3 export\ status + \beta_4 area + \beta_5 activity + \mu \quad (1)$$

$$Npg/nsg/change\_turnover = \beta_0 + \beta_1 Process\ Innovation + \beta_2 Firm\ age + \beta_3 export\ status + \beta_4 area + \beta_5 activity + \mu \quad (2)$$

$$Npg/nsg/change\_turnover = \beta_0 + \beta_1 Marketing\ Innovation + \beta_2 Firm\ age + \beta_3 export\ status + \beta_4 area + \beta_5 activity + \mu \quad (3)$$

$$Npg/nsg/change\_turnover = \beta_0 + \beta_1 Product\ Innovation + \beta_2 Process\ Innovation + \beta_3 Marketing\ Innovation + \beta_4 Firm\ age + \beta_5 export\ status + \beta_6 area + \beta_7 activity + \mu \quad (4)$$

Here, the dependent variables are firm performance variable includes productivity growth, sales growth, and change in turnover which are applicable in given four models. The key independent variables include “product innovation” “process innovation” and “marketing innovation” which are binary in nature, while the control variables include firm age, exporting status, area and industrial activity. In the first three models, the product, process, and marketing innovations were considered separately as key variables of interest. In the final model product, process and marketing innovations were taken simultaneously as key independent variables.

5. Empirical analysis

5.1. Innovation activities in informal manufacturing enterprises

In our survey, we considered any change that positively impacts enterprises' productivity and ultimately improves its performance, as innovation. Innovation can be incremental, adaptive and radical. Incremental innovation occurs when a firm makes minor changes to an existing product, process, or service to improve quality or value. Radical innovation defines a completely new product and major changes to an existing product. Innovation is divided into two types, namely: technological innovations such as product innovation as well as process innovation and non-technological including marketing innovations (Charmes et al., 2016; Lundvall et al., 2009). Product innovation aims to improve the quality of the product, either by improving the product itself or by packaging and storing the product (Polder et al., 2010). Process innovation aims to improve the process of distributing the product or service to customers.

While the latest processes and products in the enterprises consulted during the survey were not “new to the world” but those innovations are “new to the firm” which are considered for our study. It is surprising to note some of their incremental innovations. Most enterprise managers and owners did not consider modification and innovative improvements of current technologies as innovation. Innovation has been related to groundbreaking radical change by most of the firm owners. In this harsh institutional and business environment in India, every entrepreneur has great confidence and trust in the market that motivates him or her. They have learned about the business value of their

commodity on a step-by-step basis. As previously mentioned by Lundvall et al. (2009), all the innovations noted in the cases are the result of experiential learning and a method of doing, using, and interacting (DUI).

This is also clear that innovation takes place at enterprise level and in informal manufacturing firms, it takes various forms. Metal firms in India, for example, are also interested with reverse engineering products sold by formal enterprises and how inexpensive substitutes can be produced with usable materials. However, some radical innovative work of informal enterprises is still performed. Informal enterprises are innovative not just in their production of new products but also in their way of selling them– through attractive, other branding types and distinctive packaging.

Our field survey found that in informal sector firms, understanding of innovation as a term appears to be rare. Many enterprises owners often answered the question of innovation by questioning what the definition of the word "innovation". This is clear that informal entrepreneurs do not understand the academic utilization of the term "Innovation". When asked for an example of innovations newly introduced, most firms mentioned the production of new products. Non-technological (marketing) innovations have been mentioned rarely³.

Generally, it reflects the perception of innovation in terms of products in informal manufacturing enterprises. However, enterprises are also conscious about marketing and process innovations that are incentives for product innovation and are frequently implemented to accompaniment the introduction of new processes and products⁴. However, the surveyed firms still seem to focus on innovations that mainly concern the products that can be marketed. Table 1 gives the descriptive picture of innovations in the informal firms between 2015 and 2017 based on our field survey.

Table 1. Innovation Activities in Informal Manufacturing Enterprises in NCT-Delhi during the Period of 2014-15, 2015-16 and 2016-17 (combined)

Innovation activities of the enterprises	Frequency	Percentage
Technological innovations	200	66.7
Product innovation	173	63.3
Who developed product innovation		
Mainly by your firm	135	78
Your firm with the cooperation of other firm	32	18.4
Mainly by other firm	6	3.5
Degree of novelty of product innovation		
New to the market	16	9.2
New to the firm itself	144	83.3

Average (mean) percent of sales due to product innovations		
Sales due to New to the market product innovations	-	24.7
New to the firm itself	-	23.7
Marginally modified products	-	27.3
Process innovation	169	59
New or significantly improved production methods	89	52.7
New or significantly improved "logistics, delivery or distribution of products"	78	46.2
New or significantly improved supporting activity for processes	77	45.5
Who developed process innovation		
Mainly by your firm	112	66.2
Your firm with the cooperation of other firm	50	29.5
Mainly by other firm	7	4.1
Degree of novelty of process innovation		
New to the market	25	14.7
New to the firm itself	144	85.3
Marketing innovations	108	37.1
Customer loyalty rewards	83	76.5
Pricing strategies, excluding discount schemes	79	73.1
Product appearance, excluding package or branding	63	58.3
Advertisement methods	64	59.2
Promotion of the product	58	53.7
Sales channels or sales points	70	64.8
Discount schemes	61	56.4
Packaging	70	64.8
Branding. Logo, name or trademark	58	53.7
Payment schemes	49	45.3
Exporting Status of Innovating firms		
Total exporting firms	132	44
Exporting firms introducing Product Innovations	96	55
Exporting firms introducing process innovations	43	25
Exporting firms introducing marketing innovations	56	52
Attempts to develop innovation activities		
Abandoned or suspended innovation activities before completion	117	39
Any innovation activity still ongoing	137	45

Source: field survey, 2018; Note: multiple responses

It is evident from Table 2 that Product innovations in informal manufacturing enterprises are prevalent, with 64 percent of interviewed firms introducing at least one product innovation. With the introduction of new product

innovations, the average percentage sales with novelty of new to the market is nearly 25 percent whereas average sales due to the new to the firm innovations are about 24 percent. Average percentage of sales due to marginally modified product is 28 percent in our study.

Similarly, as product innovations, Process innovations are also widespread in our data. Out of the 300 informal manufacturing firms interviewed, 169 representing 59 percent of firms introduced one of the three process innovations. Descriptive analysis shows that nearly 53 percent of firms involved in process innovations improved production methods and about 47 percent and 45 percent of firms improved “logistics, distribution or delivery” and improved “supporting activities for processes” respectively. The firm itself with nearly 67 percent of sampled firms develops majority of process innovations. About 30 percent of the firms generated process innovation with the cooperation of other firms in the market. More than 85 percent of the firms introduced process innovation which are new to the firm itself and remaining 15 percent represent the new to market process innovations.

We found that Marketing innovations are relatively low in our sampled informal firms. This may be because the marketing capability of informal sector in India is very low. The table reveals that nearly 38 percent of the firms interviewed introduced at least one form of marketing innovation. The most common marketing innovation is customer loyalty incentives with nearly 77 percent of our sampled firms introducing marketing innovations. Nearly 60 percent of the firms introduced marketing innovations like changing advertisement methods and packaging⁵.

The other marketing innovations of our sampled firms are also prominent, including pricing strategies, discount schemes and sales points.

Many of the informal enterprises continue to pursue innovative activities, with about 45 percent of firms engaged in constant attempts to launch new products. Few firms, about 39 percent, have also showed abandoning innovation activities. Also, 44 percent of the total firms are exporting to the non-local markets. In this, 55 percent of the firms introducing product innovations and 52 percent of the firms introducing marketing innovations are exporting to the non-local markets. However, firms introducing process innovations are relatively low in exporting status i.e., 25 percent of firms.

Further, table 1 reveals that not all practices and experiments in innovation necessarily produce innovation. To further understand the specific innovations introduced by enterprises, we asked innovative enterprises to describe their product and process innovations

Table 2 change in turnover over last three years

Change in Turnover Compare to Last Three Years	Freq.	Percent	Cum.
Decrease	117	39.00	39.00
no change	47	15.67	54.67
Increase	136	45.33	100.00

Source: field survey, 2018

Table 2 shows that out of the total sample of 300 informal manufacturing firms that reported their total turnover over last three years, (45 percent) witnessed an increase in their turnover and nearly 40 percent of firms have experienced a decrease in their turnover in the last three years. The remaining 15 percent of firms had almost the same turnover in last three years. Most of the firms that responded decreasing turnover reported that they suffered a highly transient shock because of demonetization in India.

5.2 Descriptive Statistics

Table 3 Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
Product Innovation	273	.634	.483	0	1
Process Innovation	286	.591	.493	0	1
Marketing Innovation	291	.371	.484	0	1
Normalised Productivity Growth	300	.492	.17	0	1
Normalised Sales Growth	300	.479	.158	0	1
Export status	300	.44	.49	0	1

In our descriptive statistics (Table 3), we found that 63 per cent of the total respondent firms of our sampled units introduced product innovation. The percentage of the units that have introduced process and marketing innovations are 59% and 37% respectively. An average of 38.8% of profit ratio is evident among the sampled units. In figure 1, we see that both the performance variables sales growth rate and the productivity growth rates are normally distributed. Further, the normalised values for sales growth and productivity growth rates take minimum as value 0 and maximum as value 1 to adjust for the difference in scale. 41% of the firm are exporting among total of 300 firms.

5.3. Econometric results

This section presents the effect of innovations on firm performance measured in terms of productivity growth, sales growth and profit ratio. In addition, it also presents the effect of innovations on the qualitative response of change in turnover in the last three years. Tables 6 and 7 presents the results of the effect of innovations on productivity growth, sales growth using Tobit model.. In Table 4 Column (1,2, 3) and column (5,6,7) examine the product innovation, process innovation and marketing innovations separately. column (4) and column (8) reports the results as derived from the simultaneous effect of product, process and marketing innovations on firm performance variables.

In other words, we examine the effect of product, process and technological and marketing innovations on productivity growth and sales growth. For this purpose, we categorized innovation outcomes into four categories of product, process and marketing innovations.

As already explained in the methodology section, we have normalised the sales growth and productivity growth into a scale of 0 to 1 and applied the Tobit model for our estimations. The successful introduction of new product, process and marketing innovations reap benefits to the firms in terms of sales and productivity increase. Both product innovation and marketing innovations, influence sales growth as well as productivity growth significantly⁶. However, the process innovation has insignificant impact in comparison with product and marketing innovations. Although, process innovation has shown significantly positive impact on both productivity growth and sales growth where product and marketing innovations were not controlled.

Table 4. Effect of Innovations on Productivity Growth and Sales Growth

VARIABLES	Estimation Method: Tobit Model							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Normalised Productivity Growth				Normalised Sales Growth			
Product Innovation	0.192*** (0.0200)			0.159*** (0.0362)	0.163*** (0.0182)			0.103*** (0.0367)
Process Innovation		0.142*** (0.0202)		-0.00663 (0.0307)		0.115*** (0.0173)		-0.0221 (0.0316)
Marketing Innovation			0.135*** (0.0187)	0.0723*** (0.0232)			0.179*** (0.0165)	0.146*** (0.0205)
Export status	9.74e-05 (0.0219)	0.0284 (0.0221)	0.0585*** (0.0203)	-0.00108 (0.0218)	-0.000835 (0.0215)	0.0251 (0.0207)	0.0249 (0.0161)	-0.00312 (0.0195)
Firm age	-0.000241 (0.00100)	-0.000475 (0.00111)	-0.000248 (0.00121)	-0.000188 (0.00102)	-0.00107 (0.00112)	-0.00132 (0.00115)	-0.00112 (0.000996)	-0.000951 (0.000980)
Area	yes	yes	yes	yes	yes	yes	yes	yes
Activity	yes	yes	yes	yes	yes	yes	yes	yes
Constant	0.353*** (0.0344)	0.388*** (0.0321)	0.413*** (0.0307)	0.348*** (0.0335)	0.365*** (0.0308)	0.401*** (0.0293)	0.400*** (0.0250)	0.355*** (0.0267)
Observations	271	284	289	271	271	284	289	271
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Log likelihood	165.609	159.668	163.745	172.236	179.227	174.742	215.667	211.244

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Exporting status is important both for sales growth and productivity growth but it does not have significant impact on firm performance with respect to product and process innovations. This indicates that informal firms are impacted more by the introduction of product and process innovations than their exporting status. This highlights the importance of local market for the informal manufacturing enterprises⁷. This result may be explained by the basic understanding of what sells and what does not sell in local product markets by informal manufacturing enterprises. This can be understood as combination of two advantages that informal forms enjoy -- 1) informational advantage in exploiting market niches in local areas and 2) advantage of low cost of production owing to use of local resources. Frequent and intense interaction of the firm with suppliers and buyers in an informal environment enables almost immediate transmission of information to action centers of individual firms which allows for seamless adaptation to the changing demands of consumers, particularly at the bottom of the pyramid, through new and cheaper products provide a valuable competitive advantage to informal manufacturing enterprises⁸.

However, exporting firms have improved the sales growth and productivity growth via marketing innovation, and we thus find that it significantly influences firm performance. These results indicate that firm owner should focus more on innovations as they are important tools for achieving sustainable competitive advantage. Improved firm performance depends on the extent of innovation implementation. Firms with resources to develop their innovative capabilities might predict a greater increase in their production efficiency, that is, productivity growth if they promote and undertake innovation activities. It is also found that the market performance indicators, namely sales growth and profit ratio, are impacted by the type of innovation conducted by firms.

In addition to both technological innovation types (product and process) being favorably and substantially correlated with some facets of firm efficiency, we find that non- technological innovations, that is marketing innovation, indeed play a fundamental role in innovative capabilities as it has the highest regression coefficient with firm performance indicators (column (5)). Lin and Chen (2007) also support this finding. Marketing innovations not only create a suitable climate for other forms of technological innovation but also have a clear, direct effect on firm performance. Based on our sample it is therefore safe to suggest that firms must pay more attention to non-technological innovations, since they play a crucial role in technological advancements. Product and process innovation is also a vital engine of firm success. Thus, firm owners should spend more on innovative capabilities and encourage new attempts to introduce innovations of any kind. Innovative performance might play the most important role in this scheme as it serves as a platform where positive outcomes of innovation types are collected and then conveyed to firm performance metrics.

Further, to check for robustness of the results, an alternative form of firm performance indicator has been considered as the dependent variable to examine the effect of innovations on firm performance. Table 5 presents results from the multinomial logit model on innovation outcomes that affect the change in turnover as qualitatively revealed by informal sector entrepreneurs. The base category is the revealed increase in turnover for the last three years. In terms of innovation outcomes, the probability to decrease in turnover is negatively associated with the innovation outcomes – reflecting the innovation outcomes are positively associated with the increase in turnover over the last three years.

In model specifications we find that innovation activities the odds of reporting an increase in turn-over by the firm. This indicates that higher innovation outcomes will make it more likely for the informal manufacturing enterprises to experience an increase in turnover, and this is observed from the high values of the coefficients for all the cases except for process innovations in simultaneous effect.

Table 5. Effect of Innovation in change in Turn Over

Estimation Method: Mlogit Model (Change in Turnover); base: Increase								
VARIABLES	(1) decrease	(2) no_change	(3) decrease	(4) no_change	(5) decrease	(6) no_change	(7) decrease	(8) no_change
Product Innovation	-4.977*** (0.657)	-2.886*** (0.658)					-3.275*** (1.002)	-2.920*** (0.931)
Process Innovation			-3.954*** (0.493)	-1.858*** (0.522)			-1.010 (0.667)	-0.324 (0.722)
Marketing Innovation					-2.135*** (0.413)	-0.830** (0.371)	-0.818 (0.541)	-0.347 (0.424)
Export status	-0.238 (0.531)	0.785 (0.524)	-1.079** (0.484)	0.318 (0.445)	-2.356*** (0.402)	-0.190 (0.372)	-0.178 (0.534)	0.793 (0.532)
Firm age_	0.00468 (0.0317)	-0.00249 (0.0280)	0.00971 (0.0272)	-0.00211 (0.0267)	0.00965 (0.0239)	-0.00524 (0.0255)	0.00115 (0.0323)	-0.00248 (0.0282)
Area	yes	yes	yes	yes	yes	yes	yes	yes
Activity	yes	yes	yes	yes	yes	yes	yes	yes
Constant	3.466*** (0.996)	0.550 (0.926)	2.873*** (0.757)	0.00924 (0.795)	1.409** (0.554)	-0.803 (0.705)	3.869*** (0.993)	0.573 (0.917)
Observations	271	271	284	284	289	289	271	271
Wald chi2	107.23	107.23	109.74	109.74	68.21	68.21	117.38	117.38
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.3659	0.659	0.3288	0.3288	0.2211	0.2211	0.3809	0.3809

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Dealing with Possible Endogeneity Problems

As is well known, above firm performance equations estimating Tobit and Mlogit model approaches might result in misleading inferences of the causal impact of introduction of different types innovation on firm performance, given the variables that account for innovation types are correlated with a potential endogeneity concern. One plausible is that we have a course of causality in the manner in which the firm performance is influenced by the implementation of different innovation types. On the other hand, there is an opposite causal direction from the firm's performance in influencing the adopting the different

types of the innovation. For example, a firm looking to improve its performance may choose a certain type of innovation to improve its reputation, which may in turn have a positive effect on its performance. Therefore, the causality may not only be that embracing the type of innovation will have an effect on business performance, but also that performance can influence the types of innovation. It is likely that the type of innovation has a potential endogeneity problem associated with the firm performance. The firm's probability to introduce innovation is likely to be correlated with other unobserved factors that may also effect the firm performance (i.e. correlated with the error term). The endogeneity problems may lead to inconsistent estimates in linear models. Thus, we seek an empirical technique that identifies variabilities in innovation that is exogenous to firm performance. To address this potential endogeneity problem, we used the export status of informal enterprises as an instrumental variable for innovation types. The idea here is that firms with exporting status in the market are able to implement relatively higher innovations than their counterparts to improve their firm performance. Firstly, the chosen instrumental variable (export status of the firm) should influence the firm performance only through the endogenous or treatment variable i.e., types of innovation. Secondly, the instrument variable (export status of the firm) must be highly correlated with types of innovations (refer appendix: table A2). Thus we further estimated sequence of defined regression models using the "Two-Stage Least Square" (2SLS) method as a robustness test in order to resolve this possible endogeneity problem.

Firstly, we have applied probit model to determine the impact of instrument variable (export status) on innovation outcomes to obtain the estimated coefficients and to generate predicted innovation variable. See equation (5):

$$p(\text{invn}=1) = \beta_0 + \beta_1 \text{export\_f} + \beta_2 \text{firmage} + \beta_3 \text{area} + \beta_4 \text{activity} + \mu \quad (5)$$

where innovation 'invn' as dependent variable is defined as before, 'export_f' is the instrumental variable of choice (i.e. export status of the firm), other controlled variable firm age assumed to influence firm innovation. Industry and location of the firms considered as fixed dummies and μ is an error term.

In the second stage, we applied $\text{predicted}^{\wedge}$ innovation variable as an independent variable to evaluate the impact of innovations on firm performance using OLS Model for productivity growth, sales growth of the firm. See equation (6):

$$\begin{aligned} \text{Productivity growth or sales growth} = & \beta_0 + \beta_1 \text{p\_prodin}(\text{or}) \text{p\_procinv} (\text{or}) \\ & \text{p\_markinv} + \\ & \beta_2 \text{firmage} + \beta_3 \text{area} + \beta_4 \text{activity} + \mu \end{aligned} \quad (6)$$

β_1 as the coefficient estimate found after considering the potential endogeneity of innovation types. The method applied is a way of accounting for potential problems related to the factors that account for the innovation variable.

Table 6 shows the results from the second stage 2SLS estimation method (refer appendix: Table A for First stage model). It is clearly demonstrated that, comparatively, across all the stated models, the findings still remain compatible with the key results of the study i.e., product, process and marketing innovations have positive significant impact on productivity growth, sales growth and profit ratio of the informal firms. Consequently, this implies that the main findings contributing to the impact of innovation types on firm performance do not suffer from reverse causalities (endogeneity problems) or omitted variables, which may have resulted in correlated error terms.

Table: 6 Second Stage (2SLS) Model: impact of innovation on growth performances

OLS Models

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
		Productivity Growth			Sales Growth	
Product Innovation	32.65*** (5.362)			34.20*** (5.710)		
Process Innovation		32.92*** (5.486)			33.85*** (5.750)	
Marketing Innovation			58.30*** (9.894)			61.32*** (10.45)
Firm age	-0.0269 (0.224)	-0.0711 (0.226)	-0.0817 (0.225)	-0.0872 (0.238)	-0.140 (0.241)	-0.144 (0.239)
Area	Yes	yes	yes	yes	yes	yes
Activity	Yes	yes	yes	yes	yes	yes
Constant	-28.05*** (284)	-27.00*** (180)	-30.28*** (422)	-9.589 (426)	-7.975 (285)	-12.03* (572)
Observations	296	296	296	286	286	286
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
R-squared	0.246	0.241	0.246	0.274	0.266	0.275

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Discussion and Conclusion

This paper aims to assess the impact of innovations on firm performance in informal manufacturing enterprises. To achieve this, we utilized primary survey data conducted in NCT-Delhi, India. Based on the firm-level data, we observe that innovative firms have higher productivity growth, sales growth, and profitability. For these success parameters, all three types of innovation play an effective role. Further, this highlights the importance of local market for the informal manufacturing enterprises as these firms mainly serve the local market in their neighborhood and surrounding regions. However, firms exporting other areas have improved the sales growth and productivity growth via introducing marketing innovation, and we thus find that it significantly influences firm performance.

The reason behind the focus of informal sector enterprises' innovation on local markets is a matter of scale⁹. Informal enterprise need to focus on local markets to be competitive in the market, but this does not imply that they lack knowledge regarding big markets. One way to achieve this, as informal enterprises do, is to try to use the so-called 'piggyback' method to access larger markets, which first attract customers with the specialized local product and then continue with a more predictable product when a buyer supplier interaction is firmly in place. These approaches, which emphasize the use of local markets, enable many informal enterprises to cope better with market uncertainties and economic uncertainties.

The econometric findings show the significance of innovation, at least in terms of increasing productivity in the firm. The findings can have major effects not only for informal enterprises in India but also for other developing countries. As earlier studies have shown, the fact that enterprises depend on increasing their innovation capacity is essential in the market. This enables them to evolve, build or sustain a competitive advantage and hence play a better role in driving domestic growth. Innovation outputs have been demonstrated to be very crucial for informal manufacturing enterprises. These results have several implications for innovation policies in developing countries, particularly India. To conclude, this study provides empirical evidence on the firm level innovations and its implications for the informal sector, which are key source of employment, livelihood and social transformation.

References:

- Atuahene-Gima, K. (1996). Market orientation and innovation. *Journal of Business Research*, 35(2), 93–103. doi:10.1016/0148-2963(95)00051-8
- Baer, M., & Frese, M. (2003). Innovation is not enough: Climates for initiative and psychological safety, process innovations, and firm performance. *Journal of Organisational Behavior*, 24(1), 45–68. doi:10.1002/job.179
- Baker, W. E., & Sinkula, J. M. (2002). Market orientation, learning orientation and product innovation: Delving into the organization's black box. *Journal of Market- Focused Management*, 5(1), 5–23. doi:10.1023/A:1012543911149
- Bernard, A. B., & Jensen, J. B. (1999). Exceptional exporter performance: cause, effect, or both?. *Journal of international economics*, 47(1), 1-25.
- Bigsten, A., & Gebreeyesus, M. (2007). The small, the Young, and the productive: Determinants of manufacturing firm growth in Ethiopia. *Economic Development and Cultural Change*, 55(4), 813–840. doi:10.1086/516767
- Braunerhjelm, P. (1996). The relation between firm-specific intangibles and exports. *Economics Letters*, 53(2), 213–219. doi:10.1016/S0165-1765(96)00898-1
- Capon, N., Farley, J. U., & Hoenig, S. (1990). Determinants of financial performance: A meta-analysis. *Management Science*, 36(10), 1143–1159. doi:10.1287/mnsc.36.10.1143
- Charmes, J., Gault, F., & Wunsch-Vincent, S. (2016). Formulating an agenda for the measurement of innovation in the informal economy. In E. Kraemer-Mbula & Wunsch-Vincent (Eds.), *The informal economy in developing nations: Hidden engine of innovation?* (pp. 336–370). Cambridge: Cambridge University Press.
- Cozzens, S., & Sutz, J. (2012). *Executive Summary-Innovation in Informal Settings: A Research Agenda*.
- Crépon, B., Duguet, E., & Mairessec, J. (1998). Research, innovation and productivity: An econometric analysis at the firm level. *Economics of Innovation and New Technology*, 7(2), 115–158. <https://doi.org/10.1080/10438599800000031>
- Damanpour, F., Szabat, K. A., & Evan, W. M. (1989). The relationship between types of innovation and organisational performance. *Journal of Management Studies*, 26(6), 587–602. doi:10.1111/j.1467-6486.1989.tb00746.x
- Daniels, S. (2010). *Making do: Innovation in Kenya's informal economy*. CO: Analogue Digital Department for Infrastructure and Economic-operation.

- De Beer, J., Fu, K., & Wunsch-Vincent, S. (2013). The informal economy, innovation and intellectual property – Concepts, metrics and policy considerations. Economic Research Working Paper no. 10. WIPO Economics and Statistics Series.
- Dougherty, D. (1992). A practice-centered model of organizational renewal through product innovation. *Strategic Management Journal*, 13(S1), 77–92. doi:10.1002/smj.4250131007 pp.-77–92.
- Drucker, P. F. (1993). *Butterworth: Post-Capitalist Society*. NY: Heinemann.
- Dunne, P., & Hughes, A. (1994). Age, Size, Growth and Survival: UK Companies in the 1980s. *Journal of Industrial Economics*, 42(2), 115–140. doi:10.2307/2950485
- Evans, D. S. (1987). The relationship between firm growth, Size and age: Estimates for 100 manufacturing industries. *Journal of Industrial Economics*, 35(4), 567–582. doi:10.2307/2098588
- Gebreeyesus, M. (2009). Innovation and microenterprises growth in Ethiopia. In A. Szirmai, W. A. Naudé & M. Goedhuys (Eds.), *Entrepreneurship, innovation, and economic development*. Oxford: Oxford University Press.
- Gopalakrishnan, S. (2000). Unraveling the links between dimensions of innovation and organizational performance. *Journal of High Technology Management Research*, 11(1), 137–153. doi:10.1016/S1047-8310(00)00024-9
- Hart, K. (2006). Bureaucratic form and the informal economy. In B. Guha-Khasnabis, R. Kanbur & E. Ostrom (Eds.), *Linking the formal and informal economy* (pp. 21–35). Oxford: Oxford University Press.
- Heeks, R., Foster, C., & Nugroho, Y. (2014). New models of inclusive innovation for development. *Innovation and Development*, 4(2), 175–185. doi:10.1080/2157930X.2014.928982
- Hoffecker, E. (2018). *Local Innovation: what it is and why it matters for developing economies*. D-Lab Working Papers: NDIR Working Paper, 1.
- International Labour Organization. (1972). *Employment, Incomes and Equality: A strategy for increasing productive employment in Kenya*. Geneva: International Labour Organization.
- Joseph, K. J., Kakarlapudi, K. K., & Arun, T. (2021). Reconciling higher productivity with innovation paradox mode of learning and innovation in India's manufacturing sector. *Innovation and Development*, DOI: 10.1080/2157930X.2021.1988421
- Jovanovic, B. (1982). Selection and the evolution of industry. *Econometrica*, 50(3), 649–670. doi:10.2307/1912606

- Kraemer-Mbula, E., & Wunsch-Vincent, S. (2016). *The informal economy in developing nations: Hidden engine of innovation?* Cambridge: Cambridge University Press.
- Lin, C. Y., & Chen, M. Y. (2007). Does innovation lead to performance? An empirical study of SMEs in Taiwan. *Management Research News*, 30(2), 115–132.
- Lundvall, B.-A., Joseph, K. J., Chaminade, C., & Vang, J. (Eds.). (2009). *Handbook of innovation systems and developing countries*. Cheltenham, UK: Edward Elgar Publishing.
- Mairesse, J., & Mohnen, P. (2010). Using innovations surveys for econometric analysis. *Handbook of the Economics of Innovation*, 2, 1129–1155. [https://doi.org/10.1016/S0169-7218\(10\)02010-1](https://doi.org/10.1016/S0169-7218(10)02010-1)
- Miller, W. L. (2001). Innovation for business growth. *Research-Technology Management*, 44(5), 26–41. doi:10.1080/08956308.2001.11671451
- Mytelka, L. (2000). Local systems of innovation in a globalized world economy. *Industry and Innovation*, 7(1), 33–53
- Oke, A. (2007). Innovation types and innovation management practices in service companies. *International Journal of Operations and Production Management*, 27(6), 564–587. doi:10.1108/01443570710750268
- Olson, C. A., & Schwab, A. (2000). The performance effects of human resource practices: The case of interclub networks in professional baseball, 1991–1940. *Industrial Relations*, 39, 553–577
- Organization for Economic Co-Operation and Development (OECD) and Eurostat. (2005). *Oslo manual. Guidelines for collecting and interpreting innovation data* (3rd ed). Paris: Organization for Economic Co-Operation and Development.
- Polder, M., Leeuwen, G., Mohnen, P., & Raymond, W. (2010). *Product, process and organisational innovation: Drivers, complementarity and productive effects*. Scientific Series.
- Sen Gupta, A., Srivastava, R. S., Kannan, K. P., Malhotra, V. K., Yugandhar, B. N., & Papola, T. S. (2009). *Skill formation and employment assurance in the unorganised sector, national commission for enterprises in the unorganized sector*, New Delhi.
- Shekar, K. C. (2021). Role of Informal Sector Competition on Innovation in Urban Formal Manufacturing Enterprises in India. *Asian Journal of Innovation and Policy*, 10(1), 1-38.
- Shekar, K. C., & Joseph, K. J. (2022). Determinants of innovation and interactive learning in informal manufacturing enterprises in India. *Science and Public Policy*.

- Shekar, K. C., & Paily, G. (2019). 'The Need for an Innovation Survey in India', Economic & Political Weekly, 54/38: 19-22.
- Subramanian, A., & Nilakanta, S. (1996). Organisational innovativeness: Exploring the relationship between organisational determinants of innovation, types of innovations, and measures of organisational performance. Omega, 24(6), 631-647. doi:10.1016/S0305-0483(96)00031-X
- Ustyuzhantseva, O. V. (2015). Institutionalization of grass-roots innovation in India. Current Science, 108(8), 1476-1482.
- Wagner, J. (2007). Exports and productivity: A survey of the evidence from firm-level data. World Economy, 30(1), 60-82.

Appendix

Table A: First stage model of 2 SLS Model

First stage model (2SLS): Probit models

VARIABLES	(1) prod_inv	(2) invany_proc	(3) any_market
Exporting status	2.131*** (0.235)	1.858*** (0.194)	0.932*** (0.163)
Firm age	0.00133 (0.0130)	0.00642 (0.0122)	0.00405 (0.0110)
Area	yes	yes	yes
Activity	yes	yes	yes
Constant	-0.0628 (0.331)	-0.183 (0.297)	-0.602** (0.289)
Observations	271	284	289
Wald chi2	92.87	98.24	37.9
Prob > chi2	0.0000	0.0000	0.0000
Pseudo R2	0.3404	0.2831	0.1153

Robust standard errors in arenttheses

*** p<0.01, ** p<0.05, * p<0.1

Notes

¹ In the Indian context, 'unorganized sector', 'unregistered sector' or 'traditional sector' can all be used as a proxy for the informal sector (Sengupta et al. 2009).

² Delhi (UT) accounts for one among the top states/UTs having highest share of enterprises in urban informal sector. Evidently, Delhi's informal sector enterprises are one among the top five states in terms of technical efficiency and GVA per worker. Hence as a first stage of stratified sampling this is extremely important to understand the innovative capabilities of informal manufacturing enterprises in NCT-Delhi, India

³ A Firm owner during survey says (Anonymous): "Our business is all about to create new ideas and deliver the ideas to our customers in the form of products."

⁴ A Firm owner during survey says (Anonymous): "New processes are often needed to develop new products, machines must be built to specification and new market development must follow."

⁵ A Firm owner during survey says (Anonymous): "What individuals buy is what they see, and packaging is part of what buyers buy. So when you come up with a better box, certainly you are, one is bound to gain more consumers, market share, some patterns will boost market share, however people are now, will see you, in another color, or see you, in another way, and will draw more consumers with any good-looking product."

⁶ A Firm owner during survey says (Anonymous): "We have experienced increased sales and gained market recognition because of the significant improvement of our products and processes."

⁷ A Firm owner during survey says (Anonymous): "We know how important it is to improve products to meet the needs of our customers in terms of service time, quality and punctuality to improve our firm performance."

⁸ A Firm owner during survey says (Anonymous): "Honestly, whenever we sell our products, we collect details regularly, we always make customers to comment (on our product), what I always do is that (I ask) is there any problem? So, I still expect them to flood me with a set of problems they face with our goods. So, we compile information on a regular basis."

⁹ A Firm owner during survey says (Anonymous): "The typical local market is generally ignored by the big players. It requires products with high added value and high quality, highly specialized, tailor-made and possibly difficult to manufacture".

A quantitative analysis of obstacles to innovation among small, micro, and medium- sized enterprises: evidence from South Africa

Siyasanga Qomoyi

Human Sciences Research Council, South Africa

Abstract

Firm-level innovation in Sub-Saharan Africa remains under-researched. To address this gap, this paper examines the obstacles to innovation faced by small, medium, and micro enterprises (SMMEs) in South Africa. Using the 2018 Business Innovation Survey, we apply the double-hurdle model to investigate factors determining a firm's decision to invest, and the intensity of innovation. Our results show that cost and institutional obstacles were significantly more important as disincentive factors for medium- sized enterprises while knowledge obstacles were significant disincentive factors for large enterprises. In addition, market obstacles hampered investment among large enterprises. Interestingly, none of these factors were found to deter innovation intensity among small and micro enterprises. The study findings suggest that there is no one-size-fits-all approach to innovation policy and intervention programmes to support innovation within firms of different sizes.

Key Words: SMMEs, innovation, deterring obstacles, revealed obstacles, innovation investment, South Africa

1. Introduction

Innovation plays a significant role in driving economic growth (Fu 2020) and contributes to firm performance and competitiveness (Kasongo, Sithole and Buchana 2021) and general firm productivity (Kahn, Sithole and Buchana 2022). Literature also emphasises the role of SMMEs in employment generation, economic growth and development, and poverty reduction (de Kok, Deijl and Velhuis-Van Essen 2013; Ayyagari, Demirguc-Kunt and Maksimovic 2011; Cravo, Gourlay and Becker 2010; Hu 2010; Bolosha, Sinyolo and Ramoroka, 2022; Mulibana and Rena 2020; Avenyo and Kraemer-Mbula 2021; Kaseeah 2013; Battersby, Marshak and Mngqibisa 2016; Ndesaulwa and Kikula 2016; Sheikh 2018; Manyati and Matsau 2019). SMMEs contribute over a third to South Africa's gross domestic product, and about two-fifths (40%) to employment (Mulibana and Rena, 2020; Bolosha et al., 2022). SMMEs sell their goods and services in flexible and affordable quantities, and in locations close to where the poor live and work, thereby improving access to goods and services for the poor (Battersby et al., 2018; Bolosha et al., 2022). Further, SMMEs establish personal relationships with their customers, which allows them to offer interest free credit arrangements (Battersby et al. 2018). Thus, it is necessary to study the barriers to innovation and factors affecting the intensity of innovation among SMMEs in Sub-Saharan Africa. In addition, the obstacles to innovation must be understood according to firm size class, or category.

Rapid industrial changes, competition and consumers' demands for good quality products at affordable costs, are some of the challenges that SMMEs have faced in recent times (Agwu et al. 2019). Technological change such as artificial intelligence and automation, has affected many aspects of business in the 21st century. Improved and constant innovation activity is critical to address these challenges and improve a firm's competitiveness. In addition, increased SMME innovation contributes to GDP (gross domestic product), which in turn contributes to domestic employment creation. Little is known about the obstacles to innovation faced by firms in Sub-Saharan Africa, although innovation is widely recognised as a major contributing factor towards firms' success (Abbey and Adu-Danso 2022).

Sub-Saharan Africa and South Africa present several studies on the determinants of innovation, however, there is limited focus on firm size and class in relation to innovation. In recent studies, Kasongo et al. (2021) and Kahn et al. (2022) found that firm size positively impacts the decision to innovate in South Africa's services and manufacturing sectors respectively. Obstacles to innovation among different firm sizes are not clearly distinguished in current research in South Africa. In this study we investigate the decisions made by SMMEs to invest in innovation and factors affecting the intensity of the firms' innovation, to understand the obstacles faced by different firms. Are SMMEs

facing similar obstacles to innovation compared to large firms? Existing literature shows that several factors drive or inhibit SMME innovation. However, most of this work is based on developed countries (e.g., Coad, Pellegrino and Savona 2016; Arza and Lopez 2021). Our understanding of the determinants and obstacles to innovation is therefore obtained in a developed country context and may not be appropriate for innovation in less developed countries in Africa (Fu 2020).

In South Africa and many other countries, SMMEs make up an important part of the private sector. According to Fongwa and Fohtung (2013), Sub-Saharan African countries have started to recognise SMMEs as key drivers of the economy. In South Africa in 2015, Stats SA reported 2,251,821 SMMEs of which 667,433 were formal and 1,497,860 informal (Bureau for Economic Research 2016). Although there is a high number of SMMEs in South Africa it is also reported that 70% to 80% of SMMEs collapse in the first year of operation (Mulibana and Rena 2020). Nonetheless, research shows that small businesses that engage in innovation are more likely to succeed or survive than those that do not engage in innovation (Mhula-Links, Hart and Jacobs 2014).

While innovation has been recognised as a contributing factor to successful businesses, SMMEs face many challenges in creating high value and market-oriented innovations. In the same vein, research (e.g., Agwu et al. 2019) highlights different characteristics that influence a firm in its innovation strategies. For this reason, it is important to understand obstacles to innovation faced by firms of different sizes. The challenges faced by firms have been exacerbated by rapid technological advancement and globalisation (Agwu et al. 2019) but how firms of different sizes overcome such challenges in low-income countries remains poorly understood.

This paper seeks to contribute to addressing two research gaps. First, the study acknowledges that much about innovation drivers and sources has been learned from studies that focus exclusively on the innovation challenges that face SMMEs in developed countries. Therefore, this study aims to participate in closing this gap by providing an analysis of data in the Sub-Saharan African context. Second, the study acknowledges existing research on the obstacles and challenges of innovation among SMMEs but argues there is little research that considers heterogeneities according to firm size when investigating a firm's decision to engage in innovation activities. In addressing this gap, the current study applies a double-hurdle model and investigates the obstacles affecting innovation and innovation intensity among SMMEs in South Africa.

2 Theoretical background and literature review

2.1 Theoretical framework

The study adopts a systems of innovation approach to understand the obstacles to innovation among SMMEs, following several other studies (e.g., Arza and

Lopez 2021). Lundvall (1992) defined an innovation system as “the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge”. As Edquist (2005) highlighted, the innovation systems approach is widely used in academic and policy circles because of its strengths. These include the holistic, interdisciplinary and evolutionary perspective it adopts, its emphasis on learning processes and the role of institutions, and the non-linear perspective it offers to innovation. The evolutionary perspective stresses that innovation processes occur over time and are influenced by several factors and feedback processes (Edquist 2005). The importance of firm capabilities, interactions and networking, learning, as well as the institutional set up, are also emphasised (Nelson 1985; Lundvall 1992).

The innovation systems approach recognises that innovation is not just a product of the individual actions of firms, but also of interactions among various actors, such as research institutions, government agencies, competitors, suppliers, etc. The holistic nature of the innovation systems approach allows for the identification of a wide array of innovation obstacles across the organisational, social, political, and economic spheres that most small and medium enterprises face. A firm’s decision to engage in innovation compels it to overcome internal and external challenges (Arza and Lopez 2021; D’Este, Iammarino, Savona and von Tunzelmann 2012). Recent literature has emphasised the importance of distinguishing deterring and revealed obstacles to innovation (D’Este et al. 2012; Arza and Lopez 2021). The former are barriers that hinder some firms from initiating innovation activities, while the latter are experienced by those firms who have passed the first hurdle and are engaged in innovation activities. Firms in developing countries also generate resources and capabilities to appropriate economic value and become more innovative (Goedhuys, Janz and Mohnen 2014). How they create firm-level resources for innovation includes internal R&D, entrepreneurial skills, and a variety of input factors. Firms require a unique set of innovation relations, capabilities, and resources, for them to engage in innovative activities regardless of their size (Saka-Helmhout, Chappin and Vermeulen 2020).

2.2 Literature review

Academic interest in the determinants and barriers of innovation is not a recent phenomenon and dates to the 1980s (Arza and Lopez 2021). Nonetheless, the study reviews more recent literature, from 2000, in both developed and developing country contexts. The OECD (2005) notes that several factors including economic factors, such as high costs, or factors specific to an enterprise such as a lack of skilled personnel or knowledge as well as legal factors such as regulations and tax rules hinder innovation activities. Savignac (2008) examined the impact of financial constraints on the propensity of French manufacturing firms to engage in innovation activities. The study restricted the sample to firms that wished to innovate and used a recursive bivariate probit model.

The results indicated that the likelihood that firms will engage in innovative activities is reduced by financial constraints. Similarly, Blanchard, Huiban, Musolesi and Sevestre (2012) distinguished between firms that intend to innovate and those that do not innovate when they assessed the impact of obstacles to innovation on French firms' propensity to innovate. The study utilised the French Community Innovation Survey (CIS4) and analysed it using a bivariate probit regression model. The variables considered included firm size, research and development (R&D) intensity, group affiliation, and region. The results indicated that the intensity of R&D plays a significant role in firms' propensity to innovate. Larger firms are more R&D intensive, thus, their ability to innovate is high. Firms that invest large amounts in R&D engage in several innovative projects and are more likely to face obstacles as they engage in innovation.

Furthermore, the impact of a firm's size on their probability of facing obstacles was significantly negative when using the sample of the firms willing to innovate, but size did not appear to have significant effects when the full sample was used (Blanchard et al. 2012).

These studies paid attention to firm size classes and how factors such as cost, market, R&D intensity as well as group affiliation, influence innovation activity. A study published by the OECD in 1997 argues that SMMEs are generally more market and less research-driven compared to large companies; they are quick to respond to new opportunities and are oriented to achieving small, incremental advances. The results also indicated that being part of a group assists in reducing the likelihood of facing obstacles.

The predominantly studied and identified obstacles to innovation are cost, knowledge and regulation factors (Galia, Mancini and Morandi 2012). Nizaeva and Coskun (2018) analysed the determinants of financial obstacles faced by SMMEs in selected emerging economies in the Western Balkan region of Europe using an ordered probit model. The main determinant of financial constraints for SMMEs in the selected economies was firm size. Ownership type, firm age, accounting information, transparency, the depth of credit information indexes, banking sector concentration, property registration costs and per capita GDP were other observed determinants of financial constraints.

Pellegrino and Savona (2017) assessed the barriers that constrain firms' investment in innovation activities using panel data from the UK Community Innovation Survey (CIS). They employed the same sampling strategy used by Savignac (2008) and excluded firms that were not innovation oriented, focusing on firms willing to innovate (measured as having introduced a new product or process or engaged in innovation activities while experiencing at least one of the barriers to innovation). The study applied a pooled probit model to analyse the data. Financial obstacles were found to significantly reduce the probability of translating innovative efforts into innovation outputs. Furthermore, firms

experiencing market-related obstacles were observed to be less likely to introduce any kind of innovative product or process than firms that did not experience market-related obstacles. A firm's propensity to introduce an innovative product or process was also significantly reduced by regulatory barriers.

Uvarova and Vitola (2019) used qualitative methods including desktop research, focus groups, and semi-structured interviews with various stakeholders to identify the main challenges and opportunities for the introduction of innovation in European rural SMMEs. The main identified shortcomings that challenged SMMEs included the environment for innovation (the lack of innovation culture and low interest in innovative solutions), inappropriate innovation policies and support measures, lack of knowledge and skills within companies, difficulties in employing new skilled labour, and a weak capacity to be competitive. Arza and Lopez (2021) studied obstacles that affect and prevent investment intensity in the innovation of firms of different sizes in Argentina's manufacturing sector and also distinguished between firms that engage in innovation activities and those that do not. Factors such as cost, market and institutional obstacles were identified in the findings as deterrents to innovation, while knowledge and market obstacles affected investment intensity in innovation. Cost obstacles affected smaller firms' investment decisions more than larger firms.

Countries in the Global South are also characterised by low levels of productivity, with labour productivity extremely low compared with countries in the Global North. Countries in the Global South lack broader factor inputs such as managerial competencies, access to information, worker motivation and institutional flexibility (Odeh 2010). Poor government policies, poor infrastructure, and lack of adequate formal and vocational education, which then hinder technology adoption, are also factors that explain the difference in productivity in these countries (Mugogo and Midala 2020).

Elmansori and Arthur (2014) used a snowball approach to survey SMMEs in Libya to identify obstacles to innovation. The shortage of financial resources, lack of innovation culture in Libyan education institutions and the shortage of skills in innovation management were identified as major obstacles to innovation. Other factors hindering innovation were insufficient use of public procurement to foster innovation in SMMEs, a shortage of skills to manage intellectual property and knowledge, and insufficient knowledge about innovation support services.

Nmadu, Sallawu and Omojoso (2015) analysed the socio-economic factors affecting the adoption of innovation by cocoa farmers in Nigeria through descriptive statistics and multinomial logistic regression using data from structured interviews. The adoption rate was found to be low, and gender, as well as the level of education of the farmers, were the main factors that affected

the decision to adopt innovation. Almost two-thirds of the farmers were male and 70 per cent had only primary school education.

Elmansori and Arthur (2014) also observed socio-economic factors, highlighting that the ownership of SMMEs in Libya was largely dominated by men and due to culture, religion, and family responsibilities, women were likely to face more constraints to innovation.

Mugogo and Midala (2020) used qualitative and quantitative approaches to examine the barriers to SMME innovation performance in Zimbabwe. They identified economic factors such as lack of finance and the high cost of innovation as key factors that constrain SMME innovation.

The topic of barriers to innovation in SMMEs has not been studied extensively in South Africa and studies that explored barriers to innovation did not specifically focus on innovation obstacles for SMMEs. Some studies have investigated the use of open innovation (Krause, Schutte and du Preez 2012) as well as challenges to ICT adoption and use, particularly in the manufacturing sector (Pillay 2016; Gono, Harindranath and Ozcan 2013). Few South African studies use quantitative methods to assess obstacles affecting SMMEs' decisions to innovate.

Ngibe and Lekhanya (2019) investigated the challenges to innovation leadership in South African manufacturing SMMEs using the factors analysis test. The results indicate that factors that affect innovative leadership in manufacturing SMMEs include education and training, leadership and technical skills, a lack of financial assistance, the effects of the South African Revenue Service, and the inability to adapt to ICT. A policy brief by Sithole, Mudavanhu, Nkobole-Mhlongo and Kupamupindi (2018) assessed how cost, knowledge, and market barriers are perceived depending on factors such as the number of innovation activities of SMMEs, the number of employees, being part of a larger group, the extent of an international corporation, the number of types of cooperation partners as well as sources of information. Cost barriers are experienced more significantly by SMME start-ups than established companies, and companies with international and other partnerships are less likely to experience cost barriers than companies without partnerships. Companies that innovate are also more reliant on qualified employees than companies that do not innovate.

Cost or financial obstacles are the most prevalent determinants of a firm's decision to innovate in many of the studies. The size of the firm is a significant determinant of the extent of the cost obstacle – smaller firms are more financially constrained than larger firms. The financial burden of innovation diminishes the innovation activity of firms. Small innovative firms face challenges such as a lack of grants and venture capital, inefficient information

exchange in the community, and investor decision-making capacity (Butryumova, Karpycheva, Grisheva and Kasyanova 2015).

Chundakkadan and Sasidharan (2020) studied the relationship between financial constraints, government support, and firm innovation in developing countries. The authors found that financial constraints were obstacles to innovation for small and medium enterprises. Furthermore, lack of finance is prominent in young and small firms due to information asymmetry (moral hazards) in the credit market and hampers investment in innovation activities in these firms. Ayalew and Xianzhi (2020) studied the effect of financial constraints on innovation in selected African countries. They found that access to finance is an obstacle to innovation and reduces the likelihood of firms introducing new or improved products or processes.

Similarly, Sharma (2017) examined managing innovation in micro, small, and medium enterprises in the Middle East and North Africa (MENA). The study found that obstacles to innovation include: lack of coordination (action and policy) frameworks to promote SMME innovation policies, scarcity of skilled human resources in innovation management, competition, improper access to markets, high barriers to entry, lack of financial resources, insufficient use of public procurement to foster innovation in small-medium enterprises, and the lack of infrastructure and technological support services.

Oudgou (2021) also examined the financial and non-financial obstacles to firms' innovation in the MENA region. The study found that small firms are more innovative. The impediments to innovation in all firm sizes include business environment factors such as access to electricity, corruption, labour regulations, inadequate human resources, and political instability. In Russia, Dubrova, Ermolina and Esenin (2019) found low innovation activity among small businesses due to financial constraints (insufficient development of credit finance), poor business cooperation, and a weak technological and production base.

3 Research methodology

3.1 Data

The paper uses secondary data from the Business Innovation Survey (BIS), which is conducted approximately every three years by the Centre for Science, Technology, and Innovation Indicators (CeSTII) in the Human Sciences Research Council of South Africa. The survey is conducted on behalf of the Department of Science and Innovation, and follows the methodological guidelines set out by the OECD's Oslo Manual. The survey round conducted in 2018, covering the 2014–2016 reference period, is used in this analysis.¹

Following the guidelines of the Oslo Manual 2005, the study population is the business enterprise sector, including manufacturing, primary industries and

services. The national business register held by Statistics South Africa provided the sample frame. A stratified random sample of firms was drawn according to Standard Industrial Classification (SIC) codes and firm size (CeSTII 2020). The sample frame included 30 SIC codes in industry sectors (mining, manufacturing, and electricity, gas, and water supply) as well as services sectors (wholesale and retail trade, transport, storage, and communication, financial intermediation, and computer and related activities) and the firms were divided into four size classes (micro, small, medium, and large) based on turnover.² Thus, there were a total of 120 strata in the frame. From the initial sample of 4 950 firms drawn, 759 were discarded as duplicates, inactive, or not traceable, resulting in a final survey sample of 4 191 enterprises. A total of 642 enterprises responded to the survey, which achieved an overall response rate of 15%.

To address any bias due to potential systematic differences between firms who responded and those who did not, a simple random sample non-response survey was conducted (CeSTII 2020). The Oslo Manual (OECD 2005) recommends this for business innovation surveys with response rates below 70%. The non-response survey targeted 493 (15% of the enterprises that did not respond to the main survey), and achieved a response rate of 68%. The probability weights were then adjusted to correct for non-response bias, so that the final sample was representative of the manufacturing and service industries in South Africa.

From the initial sample of 642 firms, a total of 81 firms were excluded because they did not engage in any innovation activity and did not identify any obstacles, following previous studies (e.g., Arza and Lopez 2021; Savignac 2008; Pellegrino and Savona 2017; Blanchard et al. 2012) that investigated innovation obstacles. The relevant sub-sample included 561 firms defined as willing to innovate or potential innovators. The potential innovative firms included those engaged in innovation activities in the 2014–2016 period, had ongoing, successful, or abandoned innovations, and experienced at least one of the barriers to innovation. A total of 15 firms did not have data on key variables and were dropped from the analysis, resulting in a final sample of 546 enterprises.

For the analysis, we used employment numbers to categorise the firms into three classes: micro and small enterprises (0–50 employees); medium enterprises (51–250 employees); and large (over 250 employees). The micro and small enterprise categories were merged because of few responses from the former.

3.2 *Econometric model and variables*

The decision to invest in innovation activities was modeled as a two-step decision process: (1) the firm decides whether to invest and (2) the firm decides

on the amount to be invested (i.e., innovation intensity). The double-hurdle model (Cragg 1971) was used to model this two-step decision process. This model was chosen over the Heckman sample selection model. The Heckman approach addresses the statistical challenge posed by cases where zero investments are made as a missing data problem. However, the issue of zero investments does not represent missing values since a zero amount of investment is a valid economic choice to be explained. The double-hurdle model produces superior estimates over the Heckman model when one is dealing with true zeros (Dow and Norton 2003).

According to the double-hurdle model, firms face two hurdles while deciding to innovate, specifically, whether to undertake any innovation investment activity and how much investment to make. This approach allows for distinguishing between fixed transaction costs, which influence only the first decision, and variable transaction costs, which can influence both decisions. In the decision stage (the first hurdle), the obstacles act as a deterrence to innovation undertaking, while they constitute revealed obstacles in the second stage (second hurdle) (Arza and Lopez 2021).

The double-hurdle model integrates and simultaneously estimates the probit model to determine the probability of innovation investment (*innov_act_deci*) and the truncated normal model for the level of investment activity (*innov_act_intensityi*). The binary variable of the decision to innovate (*innov_act_deci*), assumed to follow a probit model, was specified as follows:

$$innov\_act\_deci = 1[\gamma_0 + \gamma_1 obsti + \gamma Z_i + u_i] \quad (1)$$

where: *innov_act_deci* is a binary variable capturing the decision to invest in innovation activities, which takes the value 1 if firm *i* engaged in at least 1 innovation activity, and 0 otherwise; *obsti* are innovation obstacles experienced by firm *i*; *Z_i* is a vector of a firm, institutional and market characteristics that affect innovation; γ are the coefficients to be estimated and *u_i* is the error term.

The level of investments, *innov_act_intensityi*, assumed to have a truncated normal distribution with parameters that vary freely from those in the probit, was estimated as follows:

$$innov\_act\_intensityi = \beta_0 + \beta_1 obsti + \beta x_i + \epsilon_i \quad (2)$$

Where: *innov_act_intensityi* represents innovation intensity (total amounts in Rands invested in innovation activities per employee); *obsti* are innovation obstacles experienced by firm *i*; *Z_i* is a vector of the firm, institutional and market characteristics that affect innovation; ϵ_i is the error term, and β 's are parameters that were estimated.

Table 1 presents the description of the key variables that were used. The decision to innovate variable (*innov_act_decision*) refers to those enterprises that

engaged in at least one innovation activity. The innovation activities include intramural (in-house) research and experimental development (R&D), extramural or outsourced R&D, acquisition of advanced machinery and equipment, acquisition of new buildings, acquisition of other external knowledge, internal or external training for personnel, market introduction of innovations, other in-house or contracted out activities, lease or rental of machinery, equipment and other capital goods, acquisition of computer hardware, acquisition of computer software, in-house or contracted out activities to alter the shape, appearance or usability of goods or services and engineering activities. The innovation intensity variable (innov_act_intensity) captured the amounts in Rands spent by enterprises on innovation activities divided by the total number of employees.

Table 1. Description of key variables

Variable code	Variable description
<i>Dependent variables</i>	
innov_act_decision	Engaged in at least 1 innovation activity between 2016–2018 (1=Yes)
innov_act_intensity	Innovation activity exp. per employee (R'000)
<i>Innovation obstacles variables</i>	
zcost_index	Intensity of costs obstacles (z-values)
zknow_index	Intensity of knowledge obstacles (z-values)
zmkt_index	Intensity of market obstacles (z-values)
zinst_index	Intensity of institutional obstacles (z-values)
zall_index	Intensity of at least one obstacle (z-values)
<i>Other explanatory variables</i>	
employees	No. of firm employees in 2016
human_capital_prop	Proportion of employees with a degree or diploma in 2016
firm_age	Age of firm in 2016 (years)
group	Firm is part of an enterprise group (1=Yes)
info_sources	Total number of information sources used
info_prop	Proportion of information sources used
foreign_owned	Foreign-owned (1=Yes)
exporter	International market main market for the firm (1=Yes)
SIC Code	
2	Mining and quarrying
3	Manufacturing

4	Electricity, gas, and supply
6	Wholesale and retail trade
7	Transport, storage, and communication
8	Finance, insurance, real estate, and business services

Firms were asked to identify the factors that hamper innovation, and to rate the importance of the factors (i.e., 0=factor not experienced, 1=low, 2=medium, and 3=high). The specific obstacles were grouped into four categories: cost, knowledge, market, and institutional factors, using standardised values, following Arza and Lopez (2021). The indexes measure the intensity of obstacles as perceived by firms.

Control variables included the number of employees, human capital, firm age, part of an enterprise group, information sources, foreign-owned, and exporter. The information sources variable (info_sources) captures the number of information sources that were important for the enterprise's innovation activities. The potential information sources include the following: sources within the enterprise or enterprise group; suppliers of equipment, materials, components, or software; clients or customers; competitors or other enterprises in the sector; consultants, commercial laboratories; universities / higher education institutions; government or public research institutes; private research institutes; conferences, trade fairs, exhibitions; scientific journals and trade / technical publications; and professional and industry associations. The info_prop variable captures the proportion of the above information sources that were considered important by the firms.

4 Results and discussions

4.1 Descriptive summary

Table 2 presents the descriptive statistics for the variables in the model, and the differences between small, micro, and medium enterprises and larger enterprises. The F-test statistics indicate that cost and market obstacles are significant across micro and small enterprises as well as medium and large enterprises. The results from the table indicate that on average, the enterprises included in the sample are relatively old, existing for about 29 years. Small and micro enterprises and medium enterprises are relatively younger, with years of existence ranging from an average of 17 to 26 years, compared to larger enterprises that have been in existence for an average of 42 years. On average, the number of employees of the enterprises was just under 900, however, when observing the employment levels of the different size categories, we see that small and micro enterprises employ fewer personnel (an average of 22) while medium enterprises employ an average of 130 employees. Large enterprises on the other hand employ more personnel (more than 2 500 personnel on average). On average, 19% of the personnel in the enterprises possess a degree or

diploma. However, small, and micro enterprises have a higher proportion of personnel with degrees or diplomas compared to medium and large enterprises.

In terms of innovation decisions, it is estimated that 79% of the enterprises were engaged in at least one innovation activity but small and micro enterprises are less likely to be engaged in innovation activities than medium and large enterprises. The innovation intensity of medium enterprises is much greater than that of small and micro enterprises. The innovation intensity of large enterprises is much smaller than both small and micro enterprises and medium enterprises, which may partly be due to their much larger numbers of employees.

Cost, knowledge, and market obstacles were experienced by more than 71% of the enterprises and these obstacles are statistically significant.

Higher proportions of medium and large enterprises indicated that they experienced cost obstacles than small and micro enterprises, while a large proportion (82%) of large enterprises indicated that they experienced knowledge obstacles. Cost obstacles are the only obstacles where the size of the firm plays a significant role in the decision to innovate (Arza and Lopez 2021). Cost obstacles are significantly more important as a deterrent factor for SMME's decision to innovate than for large firms (Arza and Lopez 2021). More than 80% of small and micro as well as large enterprises experienced market obstacles, while 72% of medium-sized enterprises experienced the same obstacle. Institutional obstacles seem to be less prevalent on average but 70% of large enterprises indicated that they experienced this obstacle, compared to 60% of small and micro enterprises and medium enterprises.

Table 2. Summary of key variables by enterprise size category (n=561)

Variable	All enterprises	Small & micro enterprises	Medium enterprises	Large enterprises	F-test
innov_decision	0.79	0.66	0.82	0.88	0.000***
innov_intensity	286.55	130.85	578.21	88.12	0.314
Innov_exp (mil)	50.43	4.23	45.36	86.82	0.029**
employees	888.15	21.66	129.26	2514.20	0.000***
human_capital	0.19	0.24	0.18	0.16	0.005***
ent_age	28.93	17.15	26.43	42.24	0.000***
group	0.54	0.39	0.51	0.72	0.000***
exporter	0.16	0.16	0.12	0.21	0.061*
info_sources	5.49	3.53	5.51	7.19	0.000***

info_prop	0.50	0.32	0.50	0.65	0.000***
cost_obstacles_sum	4.85	4.57	4.78	5.17	0.454
know_obstacles_sum	4.98	3.99	4.89	5.96	0.000***
mkt_obstacles_sum	4.85	4.98	4.51	5.13	0.199
inst_obstacles_sum	2.41	2.30	2.24	2.71	0.124
all_obstacles_sum	17.09	15.83	16.42	18.97	0.028**

Source: Business Innovation Survey (CeSTII 2020)

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively.

4.2 Econometric results

The results for determinants of the probability and level of innovation for all the firms is presented in Table 3. The results show that the importance of knowledge and institutional obstacles were negative and statistically significant in the decision equation, while the cost and market obstacles were insignificant. The results imply that knowledge and institutional obstacles were associated with reduced chances of firms investing, suggesting that these obstacles are a key deterrent to investment in innovation activities by firms. However, once the decision to invest has been made, the results indicate that none of the obstacles plays a significant role in the intensity of investment. In comparison, Pellegrino and Savona (2017) found that knowledge obstacles did not show a significant relationship with the decision to invest in innovation, while knowledge and market obstacles were found to be significant barriers to the decision to innovate (Arza and Lopez 2021). Arza and Lopez (2021) further explain that deterrent obstacles are those that prevent innovation, while revealed obstacles are those that affect the intensity of firms' efforts to innovate. Knowledge obstacles were also statistically more significant compared to institutional obstacles (Arza and Lopez 2021).

Firms who relied on relatively higher proportions of information sources were more likely to decide to invest in innovation activities, but also invested at higher levels. SMMEs rarely interact with institutions outside the business sector (e.g., universities, contract research organisations, technology centres, and training institutions). Thus, information and knowledge tends to be restricted to the well-known market, leading to a dependency on either strong business partners or small markets for specialised products or services, without the ability to substitute in case the market fails (Kaufmann and Todtling 2002).

Firms with more employees were likely to invest more than those with fewer employees, among those investing. However, the number of employees did not significantly influence the decision stage of the process. A higher proportion of employees with degrees or diplomas (human capital) was associated with

higher innovation investment intensity levels for the firms that had already decided to invest. However, human capital did not seem to play a significant role in the decision stage. According to Kaufmann and Todtling (2002), small, micro and medium enterprises innovate with higher intensity than large firms. Human capital plays a key role in influencing the intensity of innovation, which indicates a need for more qualified employees (Kaufmann and Todtling 2002). In addition, SMMEs are usually unable to organise in a way that enables them to benefit from specialisation to the same extent as larger firms due to a limited resource base regarding capital and the know-how of the employees (Kaufmann and Todtling 2002). Firms with more highly educated employees are more likely to face the challenge of a shortage of qualified employees, revealing that firms with more knowledge, position themselves within niches where knowledge issues are more challenging (D'Este, Rentocchini, and Vega-Jurado, 2014 as cited in Coad, Pellegrino and Savona 2016). In addition, Coad, Pellegrino and Savona (2016) assert that firms with more highly educated employees are susceptible to other obstacles such as availability of finance, a market dominated by established firms, and regulatory barriers.

Table 3. Determinants of probability and levels of innovation activities, all firms

	Decision to invest	Innovation intensity
zcost_index	-0.038	0.100
	(0.076)	(0.141)
zknow_index	-0.188**	0.008
	(0.096)	(0.161)
zmkt_index	0.016	-0.251
	(0.084)	(0.167)
zinst_index	-0.168*	0.071
	(0.091)	(0.162)
lnent_age	-0.022	-0.081
	(0.089)	(0.156)
info_prop1	3.551***	1.249***
	(0.249)	(0.493)
human_capital_prop1	0.172	1.666***
	(0.292)	(0.496)
group	-0.193	-0.105
	(0.125)	(0.237)
exporter	0.146	0.202
	(0.174)	(0.295)
employees	0.000	0.000***
	(0.000)	(0.000)
_cons	-0.858**	9.174***
	(0.379)	(0.775)
lnsigma		

_cons	0.667***	
	(0.040)	
/sigma	1.949	
	(0.078)	
Sector controls	Yes	Yes
Number of obs	489	
LR chi2(15)	465.59***	
Pseudo R2	0.0583	
Log likelihood	-3761.67	

Source: Business Innovation Survey (CeSTII 2020)

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively.

Table 4 displays the results presented according to the firm size category. The results show that for micro and small firms, the obstacles do not play a significant role in both the decision and intensity stages. This differs among medium-sized firms, where the cost and institutional obstacles are associated with reduced chances of firms deciding to engage in innovation activities. However, once the decision to invest has been made, none of the obstacles plays a significant role. Among large firms, knowledge obstacles reduce the likelihood of firms deciding to invest. In contrast, market obstacles are associated with an increased likelihood to invest among large firms. Similarly, firms facing cost obstacles were more likely to invest in innovation activities. These results contrast with Arza and Lopez (2021) who found that cost obstacles were more critical as deterrent obstacles for SMMEs, reducing the likeliness to invest, but were not statistically significant for large firms. Pellegrino and Savino (2017) also found that financial obstacles significantly reduce both small and large firms' probability of innovating. Financial and non-financial obstacles were found to play a significant role in hampering the innovation performance of French small and large firms (Blanchard et al. 2012).

Institutional obstacles are significant for medium-sized firms' decision to innovate. On the other hand, information sources are important in the decision to invest as well as the innovation intensity of micro and small enterprises as well as medium firms, while this is only significant for innovation intensity for large firms. Human capital is a significant obstacle for medium-sized firms' innovation intensity. The results show that belonging to a group plays a significant role in large firms' decision to invest, in that the likelihood to invest in innovation is low if they are part of an enterprise group. The number of employees is a significant determinant of micro and small as well as medium-sized firms' decisions to invest, while it is a significant determinant of innovation intensity among large firms.

Table 4. Determinants of probability and levels of innovation activities by firm size category

Variables	Micro and small firms		Medium firms		Large firms	
	Decision to invest	Innovation intensity	Decision to invest	Innovation intensity	Decision to invest	Innovation intensity
zcost_index	0.111	0.034	-0.225*	-0.220	-0.095	0.382*
	(0.158)	(0.287)	(0.129)	(0.215)	(0.171)	(0.227)
zknow_index	-0.283	-0.078	0.127	-0.200	-0.415*	0.123
	(0.205)	(0.378)	(0.156)	(0.260)	(0.219)	(0.238)
zmkt_index	-0.290	-0.491	-0.155	0.022	0.454***	-0.413
	(0.193)	(0.369)	(0.158)	(0.243)	(0.175)	(0.302)
zinst_index	-0.067	0.130	-0.334**	0.344	-0.157	0.164
	(0.225)	(0.352)	(0.155)	(0.254)	(0.219)	(0.261)
lnent_age	0.114	-0.129	-0.439***	-0.676**	0.166	0.410*
	(0.211)	(0.356)	(0.169)	(0.271)	(0.166)	(0.251)
info_prop1	4.607***	2.511***	3.264***	1.862**	3.739***	-1.154
	(0.931)	(0.898)	(0.451)	(0.751)	(0.467)	(1.027)
human_capital_prop1	0.039	0.379	0.378	1.805**	-0.051	1.491
	(0.657)	(0.908)	(0.575)	(0.816)	(0.943)	(1.054)
group	-0.197	-0.289	0.069	-0.235	-0.591*	0.261
	(0.285)	(0.510)	(0.217)	(0.360)	(0.341)	(0.401)
exporter	0.356	0.811	1.121***	0.097	-0.177	0.167
	(0.342)	(0.602)	(0.372)	(0.479)	(0.336)	(0.450)
employees	0.024*	-0.003	0.005**	0.000	0.000	0.000**
	(0.014)	(0.020)	(0.002)	(0.003)	(0.000)	(0.000)
_cons	-6.487	9.050***	-0.344	10.567***	-0.433	9.436***
	(260.31)	(1.147)	(0.947)	(1.384)	(0.959)	(1.229)
lnsigma						
_cons	0.611***		0.606***		0.624***	
	(0.083)		(0.064)		(0.065)	
/sigma	1.842		1.833		1.867	
	(0.153)		(0.118)		(0.121)	
Sector controls	Yes		Yes		Yes	
Number of obs	139		180		170	
LR chi2(15)	178.64***		179.35***		171.49***	
Pseudo R2	0.0928		0.0572		0.0592	
Log likelihood	-873.60		-1477.53		-1362.95	

Source: Business Innovation Survey (CeSTII 2020)

Notes: ***, **, and * means significant at 1%, 5%, and 10% levels, respectively

4.3 Obstacles to innovation

The literature has indicated that enterprises face various barriers that affect their innovation activities (OECD 2005) and their decision to engage in innovation (Kasongo et al. 2021). It has also indicated that various obstacles affect enterprises' innovation activities (OECD 2005) and their decision to engage in innovation (Kasongo et al. 2021). SMMEs share features that place them at a disadvantage compared to larger enterprises. Therefore, larger enterprises are expected to invest more in innovation than SMMEs (Azra and Lopez 2021). Our paper contributes to the empirical literature on the obstacles to innovation among SMMEs in the developing country context in Sub-Saharan Africa.

The double-hurdle model (Cragg 1971) was applied to investigate the firm's decision on whether to invest, and the firm's decision on the amount to be invested. The results from the model show diverse obstacles affecting SMMEs' innovation processes.

The results from the model showed that overall, knowledge and institutional obstacles were negative and statistically significant in the decision equation, while the cost and market obstacles were insignificant. The results imply that knowledge and institutional obstacles negatively influenced enterprises' decisions to invest in innovation. The results further revealed that these obstacles did not play a significant role after an enterprise has decided to invest. Furthermore, firms that relied on relatively higher proportions of information sources were more likely to decide to invest in innovation activities but also invest at higher levels. This demonstrates the importance of a variety of sources of knowledge and information.

We explored heterogeneities according to firm size category (SMMEs), and the results showed that for micro and small firms, obstacles do not play a significant role in both the decision and intensity stages. According to Gimenez-Fernandeza, Sanduli and Bogers (2020), existing literature does not indicate which resources are better when providing support to small enterprises. In their recent study, Gimenez- Fernandeza et al. (2020) found that start-ups will benefit more from innovation support from policy instruments that enhance external knowledge orientation than the enterprise's internal research and development. The analysis of different categories of firms showed that medium-sized firms are hampered by cost and institutional obstacles when deciding to engage in innovation activities. However, once the decision to invest has been made, none of the obstacles plays a significant role. We found that knowledge obstacles reduced the likelihood of large firms investing in innovation activities. In contrast, market obstacles are associated with an increased likelihood of investing among large firms. Similarly, firms facing cost obstacles were likely to invest more in innovation activities

The literature reviewed supported some of these findings. For instance, the

significance of cost obstacles among medium-sized firms is consistent with the findings of a study by Savignac (2008) where financial constraints were found to negatively affect innovation efforts. The finding that institutional obstacles are significant in the decision to invest in innovation is backed by Roper and Arvanitits (2012), who argue that the institutional context within which an enterprise or firm operates can hinder or enhance innovation. Market obstacles were also found to increase the propensity to invest among large enterprises. Small enterprises, on the other hand, did not consider the obstacles as deterrent factors to innovation, although the literature reviewed indicated that obstacles, particularly financial obstacles, tend to hamper the innovation capabilities of smaller enterprises.

An initial step toward highlighting suitable policies that support firms to participate in innovation activities, considering their size and their different stages of existence, is the identification of the specific obstacles that affect different firms (Coad et al. 2016), which this paper has presented. At the same time, the heterogeneity of the SMME sector presents a challenge in targeting innovation support for SMMEs that matches the specific challenges and needs of very different firms (Kaufmann and Todtling 2002). However, government can encourage the development of SMMEs and their participation in innovation activities through better access to institutional support and information by connecting SMMEs to research institutes such as universities, and offering financial support and incentives to SMMEs with an interest in participating in innovation activities.

5. Conclusion

Firms face different obstacles during the innovation process. We analysed the obstacles to innovation faced by SMMEs by using the South African Business Innovation Survey data. The analysis was done at two levels: the decision to invest in innovation and the factors influencing the intensity of innovation among SMMEs. The main results indicated that cost and institutional obstacles were significantly more important as disincentive factors for medium-sized enterprises while knowledge obstacles were significant as a disincentive factor for large enterprises. Interestingly, none of the factors was found to deter the decision to invest, or the innovation intensity, among small and micro enterprises. The findings reveal that SMMEs heterogeneity is crucial in explaining innovation and developing policy instruments to support innovation.

However, this study has not exhaustively identified all the obstacles to innovation faced by SMMEs in South Africa and more research is needed to identify the factors that constrain innovation, particularly in small and micro firms. This study paves the way for more research in Sub-Saharan Africa that compares the obstacles and also the capabilities for innovation by firm size class and categories.

References

- Abbey, E., and Adu-Danso, E. 2022. "What factors hamper innovation amongst SMEs in Kenya?" *Innovation and Development*, DOI: 10.1080/2157930X.2022.2030890
- Agwu, G.A., Agbanike, T., Uwajumogu, N., and Agbuagu, R.A. 2019. "How do firms combine different types of innovation? A multivariate probit approach." *African Journal of Science, Technology, Innovation and Development* 12(2): 1-13. DOI: 10.1080/20421338.2019.1624312
- Arza, V. and Lopez, E. 2021. "Obstacles affecting innovation in small and medium enterprises: Quantitative analysis of the Argentinean manufacturing sector." *Research Policy* 50(9): 1- 19. <https://doi.org/10.1016/j.respol.2021.104324>
- Avenyo, E. K., and E. Kraemer-Mbula. 2021. "Innovation and the Performance of Informal Enterprises in Developing Countries: A Gender Perspective." *International Journal of Gender and Entrepreneurship*. doi:10.1108/IJGE-11-2020-0174
- Ayalew, M. M. and Xianzhi, Z. 2020. "The effect of financial constraints on innovation in developing countries: Evidence from 11 African countries." *Asian Review of Accounting* 28(3): 273– 308. DOI: 10.1108/ARA-02-2019-0036.
- Ayyagari, M., Demirguc-Kunt, A. and Maksimovic, V. 2011. "Small vs. Young firms across the world", s.l.: The World Bank.
- Battersby, J., M. Marshak, and N. Mngqibisa. 2016. "Mapping the Invisible: The Informal Food Economy of Cape Town, South Africa". Cape Town: Southern African Migration Programme. doi:10.2307/j.ctvh8r2fq.
- Blanchard, P., Huiban, J.-P., Musolesi, A. and Sevestre, P. 2012. "Where there is a will, there is a way? Assessing the impact of obstacles to innovation." *Industrial and Corporate Change* 22(3): 679- 710. DOI:10.1093/icc/dts027
- Bolosha, A., Sinyolo, S. and Ramoroka, K.H. 2022. "Factors influencing innovation among small, micro and medium enterprises (SMMEs) in marginalised settings: evidence from South Africa." *Innovation and Development*. DOI: 10.1080/2157930X.2022.2092681
- Bureau for Economic Research. 2016. "The Small, Medium and Micro Enterprise Sector of South Africa." Research Note 2016 | No 1. Stellenbosch University
- Butryumova, N., Karpycheva, S., Grisheva, K., and Kasyanova, E. 2015 "Obstacles to small innovative companies' development: A case study of Nizhny Novgorod region." *Journal of Technology Management and Innovation* 10(4): 74-84. DOI: 10.4067/S0718-27242015000400008.
- Centre for Science, Technology and Innovation Indicators (CeSTII). 2020. "Innovation performance in South African businesses, 2014–2016: activities, outcomes, enablers, constraints." Human Sciences Research Council: Cape Town.
- Chundakkadan, R. and Sasidharan, S. 2020. "Financial constraints, government support, and firm innovation: empirical evidence from developing economies."

- Innovation and Development 10(3): 279–301. DOI: 10.1080/2157930X.2019.1594680.
- Coad, A., Pellegrino, G., and Savona, M. 2016. "Barriers to innovation and firms' productivity." *Economics of Innovation and New Technology* 25(3): 321-334. <http://dx.doi.org/10.1080/10438599.2015.1076193>
- Cragg, J.G. 1971. "Some statistical models for limited dependent variables with application to demand for durable goods." *Econometrica* 39(5): 829-844. <https://www.jstor.org/stable/1909582>
- Cravo, T. A., Gourlay, A. and Becker, B., 2010. "SMEs and regional economic growth in Brazil." *Small Business Economics* 38(2): 217-230. DOI: 10.1007/s11187-010-9261-z
- de Kok, J., Deijl, C., and Velhuis-Van Essen, C. 2013. *Is small still beautiful? s.l.: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).*
- D'Este, P., Rentocchini, F., and Vega-Jurado, J. 2014. "The role of human capital in lowering the barriers to engaging in innovation: Evidence from the Spanish Innovation Survey." *Industry & Innovation* 21(1): 1–19. DOI: 10.1080/13662716.2014.879252
- Dow, W. & Norton, E. 2003. "Choosing between and interpreting the heckit and two-part models for corner solutions." *Health Services and Outcomes Research Methodology* 4(1): 5-18. DOI:10.1023/A:1025827426320
- Dubrova, T. A., Ermolina, A. A. and Esenin, M. A. 2019. "Innovative activities of SMEs in Russia: Constraints and growth factors." *International Journal of Economics and Business Administration* 7(2): 26–40. DOI: 10.35808/ijeba/368
- Edquist, C. 2005. Systems of innovation. Perspectives and challenges, in: Fagerberg, J., Mowery, D.C., Nelson, R.R. (Eds.), *The Oxford handbook of innovation*. Oxford University Press, Oxford, pp 181–208. <https://doi.org/10.1093/oxfordhb/9780199286805.001.0001>
- Elmansori, E. and Arthur, L. 2014. "Obstacles to innovation faced by Small and Medium Enterprises (SMEs) in Libya." *International Journal of Innovation and Knowledge Management in the Middle East and North Africa*, 3(2). DOI:10.47556/J.IJIKMMENA.3.2.2014.4
- Fongwa, S., and Fohung, G. N. 2013. *Impact of Investment Climate Reforms on Growth and Development of SMEs: Comparisons from South Africa, Nigeria and Cameroon.*
- Fu, X. 2020. *Innovation under the radar: the nature and sources of innovation in Africa*. Cambridge University Press. DOI:10.1017/9781316869482.
- Galia, F., Mancini, S. and Morandi, V. 2012. *Obstacle to innovation: What hampers innovation in France and Italy*, Copenhagen: Druid Society.
- Gimenez-Fernandez, E. M., Sanduli, F., Bogers, M. 2020. "Unpacking liabilities of newness and smallness in innovative start-ups: Investigating the differences in innovation performance between new and older small firms." *Research Policy* 49(10). DOI:10.1016/j.respol.2020.104049

- Goedhuys, M., Janz, N., & Mohnen, P. 2014. "Knowledge-based productivity in "low-tech" industries: Evidence from firms in developing countries." *Industrial and Corporate Change* 23(1): 1-23. <https://doi.org/10.1093/icc/dtt006>
- Gono, S., Harindranath, G. and Ozcan, B. G. 2013. Challenges of ICT adoption by South African SMEs: A study of manufacturing and logistics firms. <https://www.semanticscholar.org>
- Hadjimanolis, A. 1999. "Barriers to innovation for SMEs in a small less developed country (Cyprus)." *Technovation*, 19(9): 561-570. DOI: 10.1016/S0166-4972(99)00034-6.
- Hu, M.-W., 2010. "SMEs and economic growth: Entrepreneurship or employment." *ICIC Express Letters* 4(6(A)): 2275-2280. <https://mail.tku.edu.tw/humw/t2239.pdf>
- Kahn, A., Sithole, M., & Buchana, Y. 2022. "An analysis of the impact of technological innovation on productivity in South African manufacturing firms using direct measures of innovation." *South African Journal of Economics* 90(1): 37-56. <https://doi.org/10.1111/saje.12310>
- Kasongo, A., Sithole, M., and Buchana, Y. 2021. "Empirical analysis of innovation and productivity in services firms: The case of South Africa." *African Journal of Science, Technology, Innovation and Development*. DOI: 10.1080/20421338.2021.2001207
- Kasseeah, H. 2013. "Innovation and Performance in Small- and Medium-Sized Enterprises: Evidence from Mauritius." *Innovation and Development* 3(2): 259-275. doi:10.1080/2157930X.2013.825069
- Kaufmann, A., and Todtling, F. 2002. "How effective is innovation support for SMEs? An analysis of the region of Upper Austria." *Technovation* 22(3): 147-159. [https://doi.org/10.1016/S0166-4972\(00\)00081-X](https://doi.org/10.1016/S0166-4972(00)00081-X)
- Krause, W., Schutte, C., du Preez, N. 2012. *Open innovation in South African Small and Medium-Sized Enterprises*. University Stellenbosch
- Lundvall, B.-Å. (Ed.) 1992. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning* (London: Pinter). 118 B.-Å. Lundvall
- Lundvall, B.-Å. and Nielsen, P. (1999) *Competition and transformation in the learning economy—illustrated by the Danish case*, *Revue d'Economie Industrielle* 88: 67-90. DOI: 10.4236/jhrss.2018.62036
- Lundvall, B. Å. 2007. "National innovation systems—analytical concept and development tool." *Industry and innovation* 14(1): 95-119. DOI: 10.1080/13662710601130863
- Manyati, T. K., and M. Mutsau. 2019b. "Exploring Technological Adaptation in the Informal Economy: A Case Study of Innovations in Small and Medium Enterprises (SMEs) in Zimbabwe." *African Journal of Science, Technology, Innovation and Development* 11(2): 253-259. doi:10.1080/20421338.2018.1552650.
- Mulibana, L., and Rena, R. 2020. "Innovation activities of informal micro-enterprises in Gauteng, South Africa: A systematic review of the literature." *African Journal of Science, Technology, Innovation and Development* 13(4): 425-435. DOI: 10.1080/20421338.2020.1818921

- Mhula-Links, A.L.M., Hart, T. and Jacobs, P. 2014. "The dynamics of local innovations among formal and informal enterprises: Stories from rural South Africa." *African Journal of Science, Technology, Innovation and Development* 6(3): 175-184. DOI: 10.1080/20421338.2014.940168.
- Mugogo, M. and Midala, A. S. 2020. "Barriers to SME innovation performance: evidence from Zimbabwe." *International Journal of Education and Research* 8(11): 45-58. <https://www.ijern.com/journal/2020/November-2020/03.pdf>
- Ndesaulwa, A. P., and J. Kikula. 2016. "The Impact of Innovation on Performance of Small and Medium Enterprises (SMEs) in Tanzania: A Review of Empirical Evidence." *Journal of Business and Management Sciences* 4 (1): 1-6.
- Nelson, R. R. 1985. *An evolutionary theory of economic change*. Harvard University Press.
- Ngibe, M. and Lekhanya. L. M. 2019. "Innovative leadership in South African Manufacturing Small and Medium Enterprises within KwaZulu-Natal." *Journal of Contemporary Management* 16(2): 1-31. <https://doi.org/10.35683/jcm19034.37>
- Nizaeva, M. and Coskun, A. 2018. "Determinants of the financial obstacles faced by SMEs: An empirical study of emerging economies." *Journal of Economic and Science Studies* 7(2): 81- 99. DOI: 10.14706/JECOSS17725
- Nmadu, J. N., Sallawu, H. & Omojeso, B. V. 2015. "Socio-economic factors affecting the adoption of innovation by cocoa farmers in Ondo State, Nigeria." *European Journal of Business, Economics and Accountancy* 3(2): 58-6 <https://www.idpublications.org/wp-content/uploads/2015/02/SOCIO-ECONOMIC-FACTORS-AFFECTING-ADOPTION-OF-INNOVATIONS.pdf>
- Odeh, L. E. 2010. "A comparative analysis of Global North and Global South economies." *Journal of Sustainable Development in Africa* 12(3): 338-348. <https://jsd-africa.com>
- OECD. 1997. *Small businesses, job creation and growth: facts, obstacles and best practices*, Paris. OECD. 2005. *Oslo Manual: Guidelines for collecting and interpreting innovation data*, s.l.: OECD.
- Oudgou, M. 2021. "Financial and non-financial obstacles to innovation: Empirical evidence at the firm level in the MENA region." *Journal of Open Innovation: Technology, Market, and Complexity* 7(1): 1-18. DOI: 10.3390/joitmc7010028.
- Pellegrino, G. and Savona, M. 2017. "No money, no honey? Financial versus knowledge and demand constraints on innovation." *Research Policy* 46(2): 510-521. <https://doi.org/10.1016/j.respol.2017.01.001>
- Pillay, P., and Barreira, J. 2016. *Barriers to information and communication technology (ICT) adoption and use among SMEs: A study of the South African manufacturing sector*.
- Roper, S., and Arvanitis. S. 2012. "Knowledge to added value: A comparative analysis of the innovation value chain in Irish and Swiss manufacturing firms." *Research Policy* 41(6): 1093-1106. DOI:10.1016/j.respol.2012.03.002
- Saka-Helmhout, A., Chappin, M., and Vermeulen, P. 2020. "Multiple paths to firm innovation in Sub-Saharan Africa: How informal institutions matter."

- Organization studies 41(11): 1551-1575.
<https://doi.org/10.1177/0170840619882971>
- Savignac, F. 2008. "Impact of financial constraints on innovation: What can be learned from a direct measure?" *Economics of Innovation and New Technology* 17(6): 553-569. <https://doi.org/10.1080/10438590701538432>
- Sharma, N. 2017. "Management of Innovation in Micro, Small and Medium Enterprises in the Middle East and North Africa (MENA)", in Faghih, N. and Reza Zali, M. (ed.) *Entrepreneurship Ecosystem in the Middle East and North Africa (MENA). Dynamics in Trends, Policy and Business Environment*. Springer: 611-626. DOI:10.1007/978-3-319-75913-5_23.
- Sheikh, F. A. 2018. "Undervaluation of Informal Sector Innovations: Making a Case for Revisiting Methodology." *African Journal of Science, Technology, Innovation and Development* 11(4): 505-512. doi:10.1080/20421338.2018.1532630.
- Sithole, M. M., Mudavanhu, P., Nkobole-Mhlongo, N. and Kupamupindi, T. 2018. *Barriers to innovation: Evidence from South African manufacturing companies 2010-2012. Policy brief*. Cape Town: Human Sciences Research Council. <http://hdl.handle.net/20.500.11910/11803>
- Uvarova, I. and Vitola, A. 2019. "Innovation Challenges and Opportunities in European Rural SMEs." *Public Policy and Administration* 18(1): 152-166. <http://dx.doi.org/10.5755/j01.ppaa.18.1.23134>

Notes

¹ Two of the authors were CeSTII employees and therefore had access to the data. As per the employee code of conduct in CeSTII and the HSRC, firm-level information was treated with strict confidence by all authors.

² While employment numbers are recommended by the Oslo Manual to categorise firms into different sizes, this was not possible since the business register did not have sufficient information on employment (CeSTII 2020).

Comparative Case Studies of the Industrial Transformation of the Pharmaceutical innovation system in Taiwan and India

Shih-Hsin Chen, Hung-Chi Chang, Wen-Hsin Chi
National Yang Ming Chiao Tung University, Taiwan

Abstract

This paper analyzed the development of industrial networks for international R&D collaboration, technology transfer, commercialization of scientific research, and the development of innovative industries in the pharmaceutical sector in India and Taiwan. The study uses a mixed-methods approach, combining social network and thematic analysis based on 26 interviews in Taiwan and 15 in India. Gathering data from Markeline database through social network analysis, this study mapped out the development of the strategic alliance networks of pharmaceutical sectors in India and Taiwan in the past two decades (2001-2020). The result shows both the two countries have built their networks with international collaborators, which are mainly based in the US. The pharmaceutical industries in both nations have their own advantages and disadvantages. The Indian pharmaceutical industry, although a world leader in the pharmaceutical domain, still is grappling with a lack of a strong innovation system. Taiwan's pharmaceutical sector's growth is a work in progress, and only time will tell if it can become a global hub of research excellence. To remain competitive, India and Taiwan must build their respective innovation networks to foster international and global collaborations. On the other hand, this study also found that one potential collaboration area could be developing new drugs and technologies in India and Taiwan. India's expertise in manufacturing and producing generic drugs could complement Taiwan's strengths in research and development. The two countries could collaborate to develop new drugs and technologies that are more affordable and accessible to patients worldwide. While studying the formation of the innovation network of the pharmaceuticals industry in Taiwan and India, this paper will fill the literature gaps regarding innovation systems, innovation networks,

knowledge co-production, and the development of generic drugs in Taiwan and India, which has less focused on international factors in the existing literature.

Key Words: Pharmaceutical sector, Innovation system, international collaboration, India and Taiwan

1. Introduction

The pharmaceutical industry in Taiwan has a relatively reliable legal environment, a comprehensive geographic distribution of industry clusters, access to skilled labor, sound infrastructure, innovation-driven research and development, secure intellectual property rights, and lucrative capital. Indian Pharmaceutical industry is one of the world's largest and most developed (Akhtar, 2013, Bjerke, 2022) and is still in its growth phase. Still, in the innovation system, there is a requirement to grow and improve the collaboration between governmental institutions, industry, institutions, and international players based on the innovation system. However, how has the Indian pharmaceutical industry entered the European and American markets to achieve a leading position worldwide? This paper analyzed the impact of industry policies environment on international R&D collaboration, technology transfer, scientific research commercialization, and innovative industries' development. In particular, we focus on modeling the industrial transformation, commercialization of academic research outcomes, knowledge co-production, and the development of generic drugs in Taiwan and India. The pharmaceutical industries in both nations have their advantages and disadvantages. The Indian pharmaceutical industry, although a world leader in the pharmaceutical domain, still is grappling with a lack of a strong innovation system. Taiwan's pharmaceutical sector's growth is a work in progress, and only time will tell if it can become a global hub of research excellence. In recent decades, Taiwan's success is central to its government's commitment to developing its information technology (IT) industry. India and Taiwan must build their respective innovation systems to foster international and global collaborations to remain competitive. Ultimately, this paper attempt to model the formation of the innovation system of the pharmaceuticals industry in Taiwan and India. This paper will fill the literature gaps regarding innovation system, network theory, and innovation system that has less focused on international factors in the existing literature. By examining the formation of an innovation system as an empirical case, the problem statement can be expressed as follows: "How are innovation systems formed and developed? How do institutional factors impact the evolution of the innovation system during the

technological development process?" To address the main research question, the following sub-questions are proposed:

- (1) How did India become a market leader in the pharmaceutical sector, and what lessons can Taiwan and the rest of the world draw from India's success?
- (2) How will the innovation system surrounding these two country industries help establish mutually beneficial partnerships for both nations with possible extensions to the rest of the world?

2. Literature Review

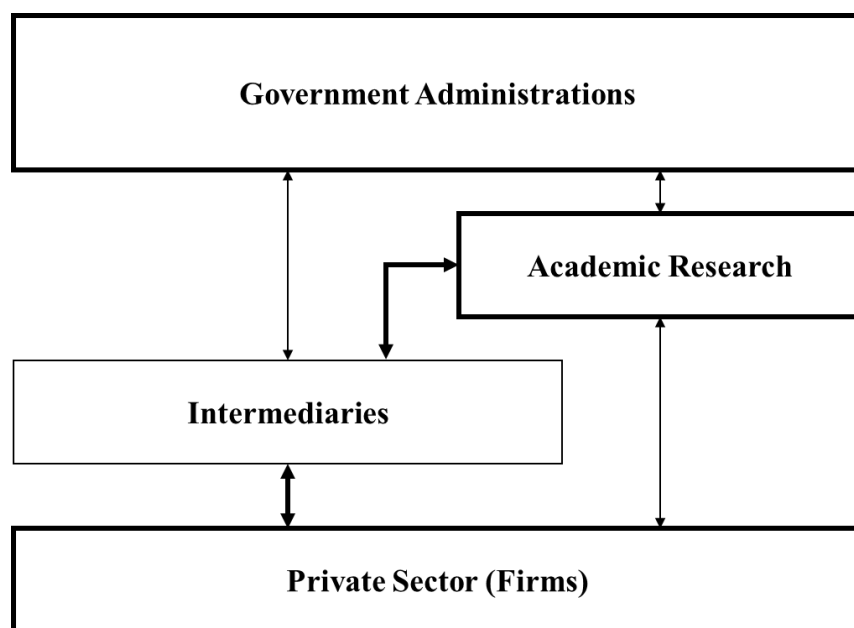
With the rapid development of the pharmaceutical industry, its definition, scope, application and technology management, and methodology are also evolving rapidly. This chapter will review the development of the pharmaceutical industry, the changes in institutional settings, and the policy context in India and Taiwan.

2.1 Systems of Pharmaceutical Innovation

Innovation is a business tool to create wealth(Drucker, 2014). in recent years, open innovation has gradually been introduced, gradually replacing closed innovation as the mainstream paradigm(Gassmann et al., 2010, Bianchi et al., 2011, Bogers et al., 2017). The innovation process is no longer viewed as a linear model but rather as an interactive process among various actors in the system, leading to the development of many derivative innovation system frameworks(Dahesh et al., 2020, Johan, 2019) such as national innovation systems(Den Hertog and Bilderbeek, 2019, Albuquerque, 2022), sectoral innovation system(Koasidis et al., 2020), technology innovation systems(Markard, 2020), and regional innovation systems(Li et al., 2022). However, due to the challenge of data collection, especially business network relationships are difficult to verify, most previous literature has conceptually explored innovation systems(Fielke et al., 2019, Klerkx and Begemann, 2020, Yigitcanlar et al., 2021, Cronin et al., 2022). This research explores the relationship between institutions and networks among Taiwan and India innovation systems using network analysis with elite interviews. This will fill the literature gaps regarding the innovation system that has less focused on international factors in the existing literature.

The innovation system in the pharmaceutical industry is a particular case to be explored, especially as it encompasses the processes of research, technology, development, and innovation. The whole process also involves processes of policy at the national level(Den Hertog and Bilderbeek, 2019, Albuquerque, 2022), institutions at the regional level(Li et al., 2022), technology at the firm level(Markard, 2020), and the attribution of intellectual property rights and technology licensing among intermediaries. In this case, networks of actors and state institutions interact in the system(Chen et al., 2022). The research on the

pharmaceutical innovation system has shown that one of the key determinants of success is the flow of knowledge among actors, particularly the transfer of knowledge between firms and partners (Braun, 2012, Qureshi, 2015, Adams, 2022). The production, transfer, and use of pharmaceutical knowledge are thought to occur in collaborative networks connecting firms, academic scientists, medical institutions, venture capitalists, and government agencies. Scholars have commented on the interaction between the actors of the Sectoral Innovation System (Faber, 2013, Malerba, 2011, Bergek, 2006, Chen, 2014). This study compiles the key actors in Sectoral Innovation System as shown in Figure 1 below.



Source: The Authors, based on Chen(2014)

2.2 Pharmaceuticals Innovation system in India

The Indian government had prioritized the pharmaceutical sector soon after the country's independence in 1947. The Indian pharmaceutical industry was dominated by foreign multinational firms, mostly from advanced countries, that established production facilities in the country due to favorable regulations and incentives provided by the government in the initial years after independence (Gereffi, 1989). However, in the 1970s, the Indian government turned protectionist and encouraged domestic firms to enter the pharmaceutical industry. Three fundamental changes in regulations had the effect of driving away foreign multinationals and stimulating domestic firms, namely The Drug

Price Control Order (DPCO), which introduced price controls in 1970, and imposed a ceiling on post-production costs for all drugs (Haakonsson, Jensen, and Mudambi, 2013, Aggarwal 2004). The Foreign Exchange Regulation Act (FERA) of 1973 imposed restrictions on foreign ownership, limiting foreign participation to no more than 49%. the Patent Act of 1970, which recognized only process patents, allowed Indian companies to sell products, even those protected by patents elsewhere, as long as the company had a new drug process. In addition, under this new patent law, the validity of patents was limited to five years. Foreign multinational companies withdrew from the Indian pharmaceutical industry in the 1970s because of the IPR protection issues arising from these regulatory changes. At the same time, domestic companies gained momentum by establishing their core competencies in active pharmaceutical ingredients (APIs) and generics through reverse engineering due to reduced competition and lax IP protection (Kale, 2012). The industry witnessed companies producing more than 400 APIs and about 60,000 generics (Greene, 2007; Lamin & Ramos, 2015); protectionism has made the Indian biopharmaceutical industry outstanding (P. Thakur-Wernz et al.) With the adoption of market-friendly reforms by the Indian government in the 1990s (Chari & David, 2012), the regulatory environment for the Indian biopharmaceutical industry changed once again. After the removal of the Wealth Management Act restrictions on foreign ownership, inward FDI picked up and foreign multinationals were once again allowed to fully own their Indian subsidiaries. In 1995, the Indian biopharmaceutical industry became attractive to foreign companies following changes in patent law following the passage of the Trade-Related Aspects of Intellectual Property Rights (TRIPS) legislation. Under the new patent law, both process and product patents were recognized and the validity of patents was extended from 5 to 20 years. With these changes, Indian biopharmaceutical companies were forced to compete with foreign multinationals in their domestic market. In order to survive and thrive in foreign competition, Indian companies sought newer markets abroad and tried to improve their almost non-existent R&D efforts by taking advantage of foreign national innovation systems (Joseph, 2015). Thus, changes since the 1990s have forced Indian firms to internationalize and innovate.

The pharmaceutical industry in India is a highly fragmented industry with more than 10,000 companies controlling 70% of the market. (Jayapala Reddy & Madhusdhan Rao, 2017). Currently, India is self-sufficient, contributing 70% of the country's bulk drug and formulation demand. Apart from meeting the local demand, the industry is also a leading global supplier of bulk drugs and formulations. There is a huge opportunity for the Indian pharmaceutical industry to expand internationally as some of the domestic drug manufacturers are compliant with international quality certifications such as US FDA and UK MCA. (Akhtar, 2013)

The Indian pharmaceutical industry is in a growth phase, but there is still a need to develop systems in the area of innovation (e.g., new molecular entities, complex generics, etc.). There is a need to develop and improve collaboration between government agencies, industry, institutions and international players, which will be based on innovation systems. (Indian Pharmaceutical Industry: A Snapshot, n.d.) On the government side important agencies in the Indian pharmaceutical industry such as the Department of Biotechnology (DBT), Department of Science and Technology (DST), National Biotechnology Development Board (NDBD), Department for Promotion of Industry and Internal Trade (DPIIT), the Office of the Principal Scientific Adviser (PSA), Pharmaceuticals Export Promotion Council (PHARMEXCIL).

National Biotechnology Development Board (NDBT), Ministry of Health and Family Welfare (MOHFW), Central Drugs Standard Control Organization-Medical Devices (CDSCO-MD), Department of Industrial Policy and Promotion (DIPP); Leading Universities, Indian Council of Medical Research (ICMR), National Institute of Medical Science (NIMS), National Institute of Biomedical Engineering (NIBE), and other important units in research. National Centre for Biological Sciences (NCBS), and the intermediaries are Venture Capitalist, Corporate Venture, Incubation Center, Biotechnology Industry Research Assistance Council (BIRAC), and Association of Biotechnology Led Enterprises (ABLE). Association of Indian Medical Device Industry (AIMED), Medical Technology Assessment Board (MTAB), Healthcare Technology Management Association of India (HTMAI), and Indian Council of Medical Research (ICMR).

However, there is also a need to promote innovation by creating a research system that will help India become an innovation-driven center for pharmaceuticals and medical devices. The innovation system includes improving the government's regulatory framework and tax interventions, innovating clinical trials by streamlining norms and rules, supporting innovation-focused startups, and providing academic institutions for cutting-edge innovation work in the field. For the development of the Indian pharmaceutical industry, it is important to expand and consolidate the global platform and cooperate with international regulators.

2.3 Pharmaceuticals Innovation system in Taiwan

Taiwan has grown its biomedical industry since the early 1980s(Wong, 2022). Due to the combination of Taiwan's strong ICT industry with industries such as 5G and healthcare(Lee et al., 2022), Taiwan's biomedical industry is divided into four main sectors: applied biotechnology, pharmaceuticals, medical devices and the healthcare sectors. The industry is crucial to Taiwan's economic growth. As of 2022, Taiwan is a member of the International Council for Harmonization of Technical Requirements for Pharmaceuticals for Human Use(Morga et al., 2023). Through this membership, it has revised all its medical laws and

regulations to international standards. The country's efforts in the sector are focused on building innovation in research and development.

Taiwan's pharmaceutical industry has several competitive advantages: a reliable legal environment, a comprehensive geographically distributed industry cluster, an acquired skills workforce, a robust infrastructure, innovation-driven R&D, secure intellectual property rights, and profitable funding and financing opportunities.(Wu et al., 2022). The government is committed to the 'five-plus-two' innovation industries for priority development, which will be the central driver of Taiwan's industrial growth in the next era. The Biomedical industry innovation program is focused on building a comprehensive system, integrating innovation clusters, and connecting global markets. (Liu et al., 2022) Taiwan's advantage in the pharmaceutical sector is attributed to its already developed high-tech industries and the knowledge and technology transfer between them. The industry also has access to educated and skilled talent. This system, coupled with the proactive policy stands by the government, has translated the industry into technology development and further into product commercialization (Hsiao et al., 2022). Taiwan's excellent R&D capabilities is proven by the very high percentage of self-developed technologies. Innovation and technological development have been a backbone for its sustainable development in the pharmaceutical industry.

Innovation and technological development have been the backbone of its sustainable development in the pharmaceutical industry. Since Taiwan has a more complete innovation system support in the government unit there is the Board of Science and Technology, Executive Yuan (BOST), National Science and Technology Council (NSTC), Ministry of Economic Affairs (MOEA), Ministry of Health and Welfare (MOHW), Taiwan Food and Drug Administration (TFDA), Ministry of Ministry of Education (MOE), National Development Council (NDC), Financial Supervisory Commission (FSC), Taiwan Center for Disease Control (TCDC), Biotechnology and Pharmaceutical Industry Program Office (BPIPO), Small and Medium Enterprise Administration (SMEA); in academic research, Taiwan National Research Institute, leading universities; and intermediaries, venture capitalists, business ventures, incubation centers, and Industrial Technology Research Institute (ITRI), Development Center for Biotechnology (DCB), National Institutes of Health (NHRI), Center for Drug Evaluation (CDE), Technology Transfer Office (TTO), Institute of Biotechnology and Pharmaceutical Industry (IBMI), and Biomedical Commercialization Center/Department of Medical Devices (BMCC). Taiwan's excellent R&D capabilities are proven by the very high percentage of self-developed technologies.

2.4 Analytical Framework

The pharmaceutical industry is a knowledge-based and intensive industry (Waterfield, 2010 Mehralian, 2013, Shen, 2021), the pharmaceutical industry is

an attractive starting point for relatively small economies wishing to establish high-value industries. Its origins in academic research, the pharmaceutical industry relies heavily on basic science, research, which is that a large part of the knowledge flow comes from research institutes and universities. Therefore, understanding where firms acquire knowledge and how they establish interactions related to knowledge transfer is a key factor in establishing an effective pharmaceutical innovation system. As technologies in the pharmaceutical industry are often created in the laboratory and eventually developed commercially by companies, exploring the interactions between different actors can provide a better understanding of the dynamic changes in the pharmaceutical industry. sectoral Innovation System considers companies as key actors and explores the interactions between stakeholders such as customers, suppliers, research institutions, etc.

The biomedical industry is regarded as a sunrise industry(Dai et al., 2022) which is a high-potential, high- return industry with high research and development (R&D) risks. Due to the high dependence on basic research, the integration of basic and applied research required for innovation takes place mainly between firms and research institutions, rather than between firms and research institutions where the interactive nature of the R&D process allows for a division of labor. Thus, actors in the value chain can benefit while the product is still being developed and it is not necessary to wait until the final product reaches the market. It is possible to link the national and firm-level characteristics of biotechnology innovation in order to identify those dimensions that are particularly salient for the sector and whose cross-country differences have been confirmed in the literature. For example, some scholars have proposed a conceptual framework for national biotechnology innovation systems based on the characteristics of biotechnology and national innovation systems, in which the scientific knowledge flows and factors that may affect specific research institutions and companies are identified(Bartholomew, 1997). Later, scholars further added the concept of sectoral, emphasizing the relevance of foreign research institutions, and further explored the impact of international relations on knowledge flows(Chaturvedi, 2005). In this study, we integrate the different frameworks of the two scholars and divide the relevant factors into three groups:

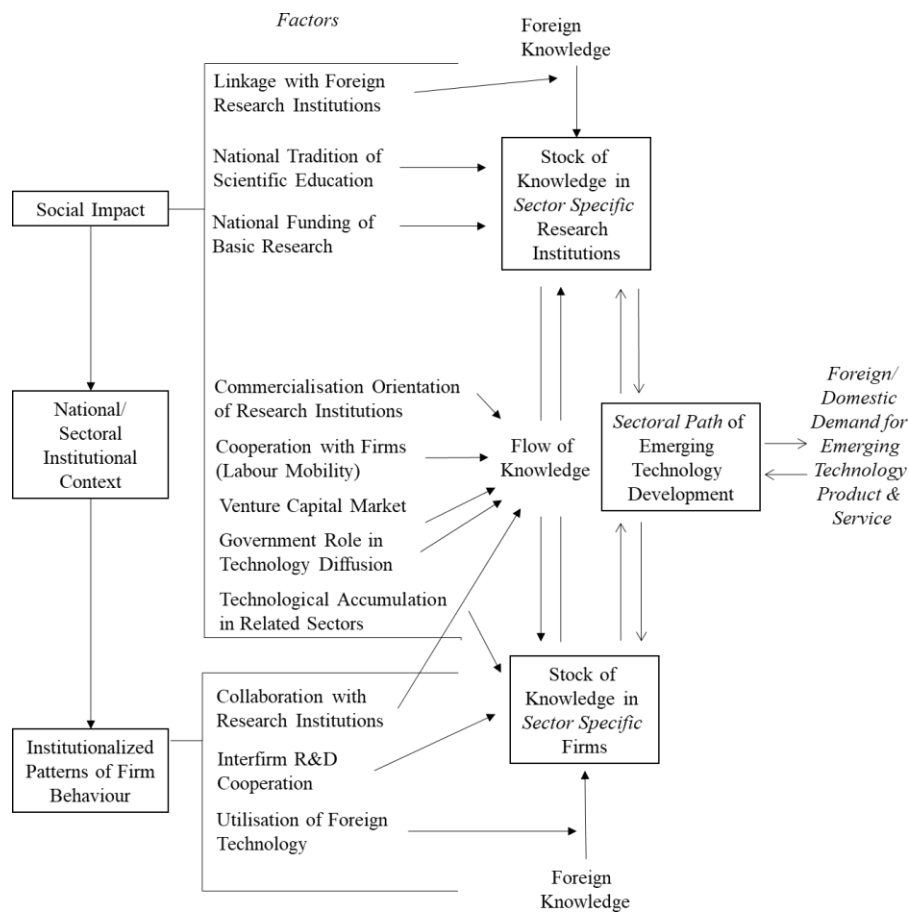


Figure 2. The conceptual framework

Source: The Authors, based on Bartholomew (1997), Chaturvedi (2005), Chen(2014)

1. factors related to the stock of knowledge in research institutions in specific sectors, including the relationship with foreign research institutions, the national science education culture, and the funding of basic research by the national team
2. Factors affecting knowledge flows, including Cooperation with research institutions, commercial orientation of research institutions, cooperation with enterprises such as labor mobility, the role of government in technology diffusion, and venture capital market
3. factors directly related to the knowledge stock of firms in specific sectors, including R&D cooperation among firms, technology utilization and technology accumulation in related sectors

3. Methodology

3.1 Research Design

This study employs a mixed-method approach, combining social network analysis from industry databases and thematic analysis based on elite group interviews fieldwork between the two research teams, this research attempt to model the formation of the innovation system of the pharmaceuticals industry in Taiwan and India, 26 interviews in Taiwan and 15 interviews in India, this study empirically examines how innovation networks in the pharmaceutical innovation system in Taiwan as well as in India have evolved in recent years and further analyzes the mediating role of intermediaries and public research institutions in the networks.

The data was collected with a combination of quantitative and qualitative data collection approaches. The quantitative data was collected from public databases, including the TEJ, MarketLine, Biomedtracker. The relationship data was further confirmed with the critical informant, and detailed interview questioning, and this set of mixed-methods studies can be initially summarized

Through social network analysis, this research hopes to know how the network of Taiwan's and India's pharmaceuticals industry changes over time, further explore the insights of building innovation systems from the context of the pharmaceuticals industry, and study the emergence of innovation systems. Furthermore, the importance of all influencing factors of the industrial transformation of the pharmaceuticals industry in Taiwan and India can be analyzed through extensive elite interviews that will be conducted to explore the factors associated with building innovation systems and the industrial transformation process.

3.2 Data collection

The data collection process in this study involves two methods: social network analysis and elite interviews. Social network analysis entails the measurement and visualization of relationships and flows among various entities, while elite interviews are conducted to collect information from industry experts regarding factors related to the establishment of innovation systems and industry transformation. Social network analysis will utilize 20 years of industry data from the MarketLine database, while thematic analysis will be applied to analyze the interview records.

3.2.1 Social network analysis

Analyzing social networks in the pharmaceutical industry in Taiwan and India provides valuable insights into the patterns of relationships and knowledge flows within these industries. Social network analysis is a methodological approach that allows us to examine the connections and interactions between

various actors, such as companies, research institutions, and individuals, and understand how these connections influence the flow of knowledge (Jamali & Abolhassani, 2006).

The four defining features of modern social network analysis - ties between actors, empirical data, graphic imagery, and mathematical/computational models (Freeman, 2004) are instrumental in studying the dynamics of the pharmaceutical industry in Taiwan and India. By representing individuals and organizations as nodes and their relationships as links, social network analysis enables us to visualize and quantify the structure and dynamics of the industry's knowledge networks. Through social network analysis, this research aims to explore how the network of the pharmaceutical industry in Taiwan and India has evolved. By analyzing the data collected from the MarketLine database, we obtained a comprehensive dataset spanning a period of 20 years, from 2001 to 2021.

By examining the patterns of connections and collaborations between different actors in the industry, we can gain insights into the knowledge flows and information exchange that occur within and between organizations. This analysis can help us understand how the pharmaceutical industry in Taiwan and India has transformed over time, identify key players and influential entities, and uncover the mechanisms driving knowledge creation, dissemination, and utilization within the industry.

3.2.2 Elite interviews

Qualitative research is exploratory, descriptive, and generative; it adopts a macro perspective and emphasizes the relationship and understanding between the researcher and the participants. It treats different topics as individual cases, is highly sensitive to the entire social structure, maintains emotional neutrality, and is relatively flexible in the overall research design (Patton, 1990). Elite interviews are commonly used data collection methods in qualitative research. This approach is employed to understand participants' thoughts on the research questions or discuss various viewpoints based on their experiences. In this study, elite interviews will focus on gathering information related to establishing innovation systems and the process of industry transformation. The data collected through elite interviews, including insights from companies, policymakers, think tank researchers, and other research institutions, will further explore the primary drivers behind international collaboration and innovation systems' role in Taiwan's pharmaceutical industry. Participants will be asked about their experiences as stakeholders in building innovation systems. For example, how they manage and foster innovation and system development, what institutional factors influence the formation of innovation systems, what policy changes affect their choices in development strategies, at what scale each collaboration operates, and what obstacles they face in commercializing their innovative products.

Additionally, thematic analysis is a method for systematically identifying, organizing, and providing insights into patterns of meaning (themes) within a dataset, enabling researchers to see collective or shared meanings and experiences across the data and make sense of them (Braun & Clarke, 2012). In this study, the thematic analysis will be applied to analyze the data collected from elite group interviews conducted in Taiwan (26 interviews) and India (15 interviews). Thematic analysis will be used to analyze the interview data and identify themes that are relevant to the research topics.

3.3 Data analysis

Data analysis examines and interprets data to gain insight and draw conclusions about a particular research topic. In this study, quantitative and qualitative data analysis methods will be used to analyze the collected data. Social network analysis will be used to analyze the structure and dynamics of the pharmaceutical industry in Taiwan over 20 years. Elite interview data will be subjected to thematic analysis to identify patterns and themes of factors associated with building innovation systems and industry transformation. Finally, the results of the two data analyses will be synthesized to provide a comprehensive understanding of the innovation system in the Taiwanese pharmaceutical industry, including its drivers, barriers, and potential for international collaboration.

3.3.1 Social network analysis

After collecting transaction data related to the pharmaceutical industry in Taiwan from the MarketLine database, we conducted a social network analysis to understand the evolution of the network over the past 20 years. Firstly, we constructed a network graph where nodes represent companies involved in the transactions, and links represent the relationships between them. To measure the structural properties of the network, various centrality measures were computed for each node. These measures included degree centrality (representing the number of direct connections a node possesses), betweenness centrality (representing the extent to which a node lies on the shortest paths between other nodes), and eigenvector centrality (representing the importance of a node based on its connections to other highly ranked nodes). Network-level metrics such as density (measuring the proportion of actual connections to the total possible connections) and clustering coefficient (measuring the tendency of nodes to cluster together) were also calculated. To understand how the network changed over time, these metrics were computed for each year in the dataset, and the results were visualized using line graphs. Community detection analysis was also conducted to identify groups of companies that tend to be tightly connected within the network.

3.3.2 interviews and Thematic analysis

The elite interviews were analyzed using thematic analysis, which is the identification, analysis, and reporting of patterns in a data set (Braun & Clarke, 2012). The process included several steps: familiarizing with the data, generating initial codes, finding themes, reviewing themes, defining and naming themes, and producing the final report (Braun & Clarke, 2012). First, the interview transcripts were read several times to familiarize with the data. Next, the primary researcher generated the initial codes, which the research team discussed and refined. The regulations were then organized and categorized into potential themes, further refined through iterative discussion and comparison. Each article was reviewed and defined by the research team, and the themes were named to represent the content accurately.

The analysis revealed several themes related to factors associated with building innovation systems and industrial transformation in Taiwan's pharmaceutical industry. These themes include policy support, talent development, international cooperation, industry-academia linkage, funding and investment, and regulatory environment. Policy support was identified as a key factor in building an innovation system. Respondents noted that policies providing funding, tax incentives, and regulatory support are important for facilitating innovation and commercialization.

4. Finding and Discussion

This section examines policy relationships, knowledge flows, and R&D networks in the pharmaceutical industry. The main focus is: how do interactions occur in pharmaceutical industry networks to develop linkages between actors and what role has been played in the emergence of networks? First, the evolution of pharmaceutical industry policies in recent years is explored. Secondly, the flow of knowledge and technology transfer is explored and the role of research institutions and industry in the networks is analyzed, with insights gained through elite interviews. This study also analyzes the niche for cooperation between Taiwan and India.

4.1 The Policy Changes in Pharmaceutical Industry

Several laws and regulations regulate the pharmaceutical industry in Taiwan. The main regulatory body is the Taiwan Food and Drug Administration (TFDA), which oversees the safety and efficacy of pharmaceuticals. The TFDA has established a pharmaceutical classification, registration, and post-market surveillance framework. The main laws and regulations that govern the biomedical industry in Taiwan. There are various government-led programs related to promoting the biomedical industry in Taiwan. With the collaboration of relevant government agencies, Taiwan's biotech industry has continued to grow in overall revenue, and there have been concrete achievements in talent

and startup team cultivation, innovation cluster construction, and database integration.

The Central Drugs Standard Control Organization (CDSCO) regulates the pharmaceutical industry in India under the Ministry of Health and Family Welfare. These rules cover various pharmaceutical-related regulations, including classification, registration, manufacturing and import, labeling, sales, post-market requirements, etc. Under this framework, roll with the CDSCO is mandatory for all pharmaceuticals. To promote the growth of the pharmaceutical industry in India, the Indian government has implemented several policy incentives and initiatives. One such initiative is the 'Make in India' campaign, which aims to encourage domestic manufacturing of pharmaceuticals and reduce the dependence on imports. The government has also implemented the 'National Biopharma Mission' to support the development of pharmaceuticals and diagnostics.

The following is a comparison of the evolution of regulations in Taiwan and India in recent years, and it can be found that the governments of both countries have had a considerable number of policy measures for the biomedical industry in recent years.

Table 1. Policy incentives and initiatives for the pharmaceutical industry in India and Taiwan

Year	Taiwan	India	Goals
1984	Strengthening Biotechnology Industry Promotion Plan		To promote the development of Taiwan's biotechnology industry by providing support for research and development, technology transfer, and human resource development.
2002	Challenge 2008: National Development Key Project		To establish Taiwan as a global leader in biotechnology by investing in research and development, infrastructure, and industry-academia collaboration.
		First National Biotechnology Development Strategy	To integrate the efforts and prepare a holistic vision and a roadmap for Indian biotechnology.
2007	Act For the Development Of Biotech And New Pharmaceutic		To support and promote the biopharmaceutical industry through various regulations and incentives, including funding, taxation benefits, recruitment, technical assistance, and

	als Industry		streamlined review processes, to establish Taiwan as a leading force in this industry.
2009	Taiwan Bio-Industry Takeoff Diamond Action Plan		Strengthening industry value chain through industrial R&D, establishing biotech venture capital fund, promoting integrated incubation mechanism, and setting up Food and Drug Administration to establish a regulatory environment for pharmaceuticals aligned with international standards.
2013	Taiwan Bio-Industry Takeoff Diamond Action Pla		To further enhance Taiwan's biotechnology industry competitiveness by providing financial and regulatory support for the development of innovative medical devices, fostering industry-academia partnerships, and promoting international cooperation
2014		Make in India	To encourage domestic manufacturing of medical devices and reduce the dependence on imports
	Taiwan Bioeconomy Industry Development Plan		To promote the development of Taiwan's bio-economy industry by leveraging Taiwan's strengths in biotechnology and innovation to create new value-added products and services.
2015		The National Biotechnology Development Strategy-2015-2020(Strategic-II)	To establish India as a world leader in biotechnology research and development by promoting the use of biotechnology to improve the quality of life for the people of India.
2015	Taiwan Bioeconomy Industry		To promote the development of Taiwan's bio-economy industry by leveraging Taiwan's strengths in biotechnology and innovation to create new value-added products and services.

	Development Plan 5+2 Industrial Innovation Plan		To transform Taiwan's economy by promoting innovation and developing new industries
2016	Biomedical Industry Innovation Promotion Plan		To promote the development of Taiwan's biomedical industry by investing in research and development, fostering industry-academia collaboration, and promoting regulatory reforms to accelerate product commercialization.
2017		National Biopharma Mission	an industry-academia collaborative mission for accelerating biopharmaceutical development in the country
2017		Innovate in India (i3) programme	To promote entrepreneurship and indigenous manufacturing in the biopharma sector
2020		Production Linked Incentive Scheme (PLI)	To incentivize large-scale manufacturing and to build required infrastructure for developing manufacturing clusters
2020		Promotion of Medical Devices Parks Scheme	To set up common infrastructure facilities for the medical device industry, thereby reducing the cost of manufacturing and promoting innovation
	Six core strategic industries to transform Taiwan		By constructing gene and health insurance big data platforms, developing precision prevention, diagnosis, and treatment care systems, as well as creating precision epidemic prevention products and expanding international biomedical business opportunities
2021		The National Biotechnology Development Strategy-2021-2025(Strategy-III)	To make India globally competitive in biotechnology research, innovation, translation, entrepreneurship and industrial growth and be a USD 150 billion Bioeconomy by 2025.

	Act for the Development of Biotech and Pharmaceutical Industry		To promote the growth of Taiwan's biotech and pharmaceutical industry by providing tax incentives and support to companies engaged in research, development, and manufacturing of new drugs, medical devices, regenerative medicine, precision medicine, digital medicine, and other strategic biotech and pharmaceutical products

Source: Own Complication

Over the past 30 years in Taiwan's pharmaceutical industry, the government has taken a number of measures to establish biotechnology research and development institutions, build biotechnology parks and incubation centers, promote the development of new drug industries, and revise relevant medical regulations and converge with international standards, all in the hope that the biotechnology industry can become the next semiconductor industry. However, the government's industrial policy plays an important role in driving the development of new drugs as the main force of the next wave of economic transformation. Based on the successful model of the electronics industry, the policy part of the R&D investment credit can increase the R&D investment of enterprises, which in turn brings positive benefits to the operating performance of enterprises and can generate the development and growth of the industry. The government passed the "Biotechnology and New Drug Industry Development Ordinance" in 2007, hoping to use industrial policy to promote the high-cost and high-risk biotech pharmaceutical industry. The Taiwan Biotechnology Take Off Diamond Action Plan, which took over from 2014-2015, is a manifestation of the government's hope to establish an environment that can converge with international regulations through food and drug management, and eventually assist and guide domestic companies to join the PIC/S GMP international quality organization, so as to promote domestic companies to become world leaders in the industry, hoping that they can meet domestic market demand and at the same time be able to We hope that the company will be able to meet the domestic market demand, and at the same time, be able to look at the international market and enter the foreign market.

On the Indian side, with a strong export market, India exports \$15 billion worth of drugs to more than 200 countries, including the highly regulated markets of the United States, Europe, Japan, and Australia. India's large pharmaceutical companies have emerged as one of the most competitive players in North America's growing generics sector and have created an unparalleled platform in

this area. Indian companies have also emerged in emerging markets around the world with a strong portfolio of products, particularly in anti-infective and antiretroviral. Large domestic pharmaceutical companies have continued to grow, taking leadership positions in many therapies and segments of the Indian market and creating a strong international export pillar, with a highly competitive market and the emergence of second-tier Indian companies with new and innovative business modules. Indian companies have also developed significant expertise in biologics capabilities. While the biologics portfolio is still in its infancy in India, it is being built with an eye on the future. Recognizing the potential for growth, the Indian government took the initiative to develop the Indian pharmaceutical industry during 2007-2008 by setting up a separate department. This department was given the responsibility of policy, planning, development, and regulation of the pharmaceutical industry. And in the last few years, the Indian pharmaceutical industry has experienced strong growth, with turnover increasing from about \$1 billion in 1990 to \$30 billion in 2015, with export turnover of about \$15 billion.

In view of the major policies announced by the Taiwan and Indian governments from 2007 to 2008 and the rapid growth from 2014 to 2015, the data in this study from 2001 to 2021 for the 20-year divided 2007 and 2014 into 2001-2007, 2008-2014, 2015-2021 three periods to analyze the changes of these periods to see the development and changes of the whole industry.

4.2 Institutions and Actors of Pharmaceutical Industry in Taiwan and India

Based on the results of literature review, industry background, interviews, and social network analysis, this study identifies the key roles in Taiwan and India as shown in the figure. Both Taiwan and India have government administrative departments and institutions dedicated to the development and regulation of the medical device industry, including: (1) regulatory and promotional agencies overseeing the pharmaceutical industry, such as Taiwan's TFDA and India's CDSCO-MD; (2) government departments focusing on promoting the biotechnology industry, such as Taiwan's BPIPO and India's DBT; and (3) government agencies responsible for intellectual property protection and promotion, such as Taiwan's SMEA and India's DPIIT.

On the other hand, Taiwan's Ministry of Science and Technology and National Science and Technology Council play a larger role in coordinating and implementing industry-related policies, while India's Department of Biotechnology and National Biotechnology Development Board are more focused on biotechnology. India has a separate department, the Department for Promotion of Industry and Internal Trade, supporting the growth and development of various industries, including medical devices, whereas Taiwan's Ministry of Economic Affairs assumes this responsibility. India has a dedicated regulatory body, the Central Drugs Standard Control Organization,

for drugs and medical devices, whereas Taiwan's Taiwan Food and Drug Administration regulates both food and drugs, including medical devices. In terms of intermediary institutions, Taiwan and India have a range of organizations and institutions supporting industry development by providing funding, resources, and expertise to entrepreneurs and startups. Regarding the role of academic research institutions, in Taiwan, universities and research institutions play a crucial role in conducting research and providing talent for the industry, while in India, the focus is more on establishing research infrastructure and supporting startups through incubation and accelerator programs.

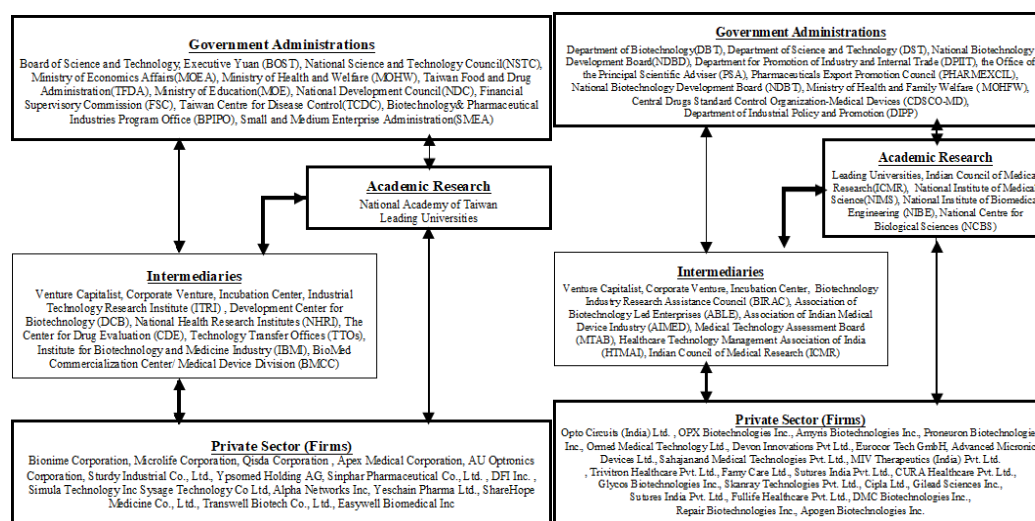


Figure 3. The Key Actors in Taiwan

Figure 4. The Key Actors in India

4.3 Knowledge Base and Technology Flow of Pharmaceutical Industry in Taiwan and India

In this chapter, we will discuss the changes in knowledge flow between Taiwan and Indian pharmaceutical industries in three time periods (2001-2007, 2008-2014, and 2015-2021). Specifically, we will introduce the top five important organizations in the pharmaceutical industry in Taiwan and India during these periods and analyze the changes among them

Table 2. Main Institution in India

Year	2001-2007	2008-2014	2015-2021
Main Institution in India	Sobha Renaissance Information Technology Pvt Ltd, Sunpa Sobha Software (China), ethica Clinical Research Inc , ethicamatrix CRO Pvt., L, Syneos Health NC LLC	Gilead Sciences Inc, Trivitron Healthcare Pvt Ltd , Trivitron Healthcare Pvt Ltd, Sterling Hospitals Ltd , Asilia Home Health	Gilead Sciences Inc, Cipla Ltd, Glenmark Pharmaceuticals Ltd, Curadev Pharma Pvt Ltd, Macleods Pharmaceuticals Ltd

During 2001-2007, the major players in the Indian pharmaceutical industry were Sobha Renaissance Information Technology Pvt Ltd, Sunpa Sobha Software (China), ethica Clinical Research Inc, ethicamatrix CRO Pvt. These companies are mainly in the field of drug trials, clinical research and information technology. This shows that the knowledge flow in the Indian pharmaceutical industry at that time was mainly from the clinical research and information technology side. And 2008-2014 period, the major players in the Indian pharmaceutical industry were Gilead Sciences Inc, Trivitron Healthcare Pvt Ltd,

Sterling Hospitals Ltd, and Asilia Home Health, which were mainly companies in the medical device and hospital sectors. This indicates that the knowledge flow in the Indian pharmaceutical industry at that time was mainly from the medical device and hospital management sectors. In 2015-2021 period, the major players in the Indian pharmaceutical industry are Gilead Sciences Inc, Cipla Ltd, Glenmark Pharmaceuticals Ltd, Curadev Pharma Pvt Ltd, and Macleods Pharmaceuticals Ltd. These companies are mainly in the areas of drug development, manufacturing, etc. These companies are mainly in the field of drug development, production, etc. This shows that the knowledge flow in the Indian pharmaceutical industry at that time was mainly in the areas of drug development and manufacturing.

In general, the main organizations in the Indian pharmaceutical industry differed in the three years, reflecting the changing knowledge flows in the industry. In the early years, knowledge flows were mainly in clinical research and information technology, while in the later years they were mainly in medical devices, hospital management, and drug development and

manufacturing. These changes indicate that the Indian pharmaceutical industry is constantly evolving and progressing to meet market demands and new challenges. This result is as explained by the interviewees:

In recent years, some Indian pharmaceutical companies and research institutes have made significant progress in the research and development of new drugs and even some US pharmaceutical companies such as Gilead Sciences Inc have started to enter the Indian market and have started to conduct drug research and development.

[(Interview, I5)]

Recently we have started to do more multinational collaborations and to explore new therapeutic areas, such as cancer treatment and gene therapy. These are the strategic directions of the company in these years.

[(Interview, I7)]

In summary, the Indian pharmaceutical industry experienced changing knowledge flows over the years, with early emphasis on clinical research and information technology, followed by a focus on medical devices, hospital management, and later on drug development and manufacturing, reflecting the industry's evolution to meet market demands and new challenges, as evidenced by collaborations with multinational companies and exploration of new therapeutic areas such as cancer treatment and gene therapy.

Table 3. Main Institution in Taiwan

Year	2001-2007	2008-2014	2015-2021
Main Institution in Taiwan	BioCryst Pharmaceuticals Inc, Shionogi & Co Ltd, Amarillo Biosciences Inc, CytoPharm, Inc., National Cheng Kung University	"National Health Research Institutes, Zentalis Pharmaceuticals LLC, Sciclone Pharmaceuticals International (Cayman) Development L, Medigen Vaccine Biologics Corp, Lopment ter for Biotechnology	Zai Lab Ltd, Sincere Pharmaceutical Group, Ocumension Therapeutics, China Medical System Holdings Ltd, Crown Bioscience Inc

In terms of knowledge flow in the pharmaceutical industry in Taiwan, from 2001 to 2007, the major institutions were BioCryst Pharmaceuticals Inc, Shionogi & Co Ltd, Amarillo Biosciences Inc, CytoPharm Inc. and National Cheng Kung University. These organizations play an important role in terms of research

institutions and universities from which they receive most of the knowledge flow. However, between 2008 and 2014, National Health Research Institutes, Zentalis Pharmaceuticals LLC, Sciclone Pharmaceuticals International (Cayman) Development L, Medigen Vaccine Biologics Corp, and Development Center for Biotechnology are gradually replacing the previous institutions as the major knowledge flow institutions, indicating a growing trend of independent research institutions and pharmaceutical companies becoming mainstream. Between 2015 and 2021, Zai Lab Ltd, Simcere Pharmaceutical Group, Ocumension Therapeutics, China Medical System Holdings Ltd, and Crown Bioscience Inc emerged as the leading knowledge flow organizations. This indicates that more and more emerging biotech and pharmaceutical companies are emerging in the industry and driving the changes in knowledge flow. Overall, the trend of knowledge flow in Taiwan has shifted from universities and research institutions to independent research institutions and emerging biotech and pharmaceutical companies. This result is as explained by the interviewees:

In the early years of the Taiwanese pharmaceutical industry, the technology came mainly from domestic research institutes and universities, so domestic research resources played an important role during this period. However, over time, Taiwan's pharmaceutical industry gradually turned to collaborating with companies and research institutions outside of Taiwan, thereby increasing the diversity and breadth of knowledge and technology.

[(Interview, T3)]

Due to regulatory restrictions, we are increasingly inclined to import semi-synthetic intermediates for improved processing, rather than developing them ourselves.

[(Interview, T12)]

In summary, the knowledge flow in the Taiwanese pharmaceutical industry has transitioned from relying heavily on domestic research institutes and universities in the early years to a growing trend of independent research institutions and emerging biotech and pharmaceutical companies driving the industry's knowledge flow, resulting in increased diversity and breadth of knowledge and technology, with a shift towards importing semi-synthetic intermediates due to regulatory restrictions.

4.3 The dynamics of the pharmaceutical industry innovation network in India

In order to understand the innovation networks of the pharmaceutical sector in India, this section maps out the networks based on the R&D collaborations in the pharmaceutical sector. Table 3 shows the network of collaboration activities in 2001-2007, 2008-2014, and 2015-2021. Each node represents one organization.

The lines between two nodes represent at least one collaboration activity (e.g. collaborative R&D, licensing, contract R&D) that was in progress in the particular year. In other words, these non-direction lines present collaboration relationships between two actors.

Table 4. The pharmaceutical innovation network in India

Table 4. The pharmaceutical innovation network in India

Year	2001 - 2007	2008 - 2014	2015 - 2021
N. of Nodes	18	75	86
N. of Edges	24	199	291
Density	0.0294	0.0072	0.0067
Average node connectivity	0.0294	0.0072	0.0725

Figure

The number of nodes in the social network of the pharmaceutical industry in India has tripled over the past 20 years. the result shows pharmaceutical industry in India is more and more popular industry area, and more and more scientists are investing in the industry. The network density indicates that the network was denser in 2001-2007 and looser in 2008-2014 and 2015-2021, with density decreasing overall. This is because it is difficult for collaborative relationships to increase together as the network grows, which also means that the pharmaceutical industry still has a lot of potential for collaboration. The average degree of nodes has increased, indicating that the development of pharmaceuticals has required more people to collaborate due to increased complexity. This also indicates that the quantity of collaboration relationships is important in pharmaceuticals. Concentration in 2008-2014 has unexpectedly decreased, indicating the reduced importance of intermediaries in forming collaborative relationships. But in 2015-2021 the concentration has increased over ten times before; this shows the pharmaceutical industry's rapid increase in the number of collaborations required:

We are also developing some forums where such collaborations can be done, industry visits from academia and vice versa can prevail. Introduction to AI and the changing dimensions of syllabus of the study will surely shorten the development time of medicine and this all seems possible if the utilization of the strengths is at a mutual stage.

[(Interview, I5)]

The collaboration between pharmaceutical companies and academia can help drive innovation and accelerate the development of new drugs and therapies. As the academic infrastructure in India continues to develop, there is a significant opportunity to harness the knowledge and expertise of academic researchers to drive innovation and advance healthcare in the region.

[(Interview, I7)]

The interview data expanded the analysis to reveal the perceptions of key players in the network about the development of intermediaries and the institutional environment, and moreover, the need for urgent collaboration with others in India, making the establishment of a complete innovation system imperative.

4.4 The dynamics of the pharmaceutical industry innovation network in Taiwan

In order to understand the innovation networks of the pharmaceutical sector in Taiwan, this section maps out the networks based on the R&D collaborations in the pharmaceutical sector. Table 4 shows the network of collaboration activities in 2001-2007, 2008-2014, and 2015-2021.

Table 5. The pharmaceutical innovation network in Taiwan

Table 5. The pharmaceutical innovation network in Taiwan

Year	2001 - 2007	2008 - 2014	2015 - 2021
N. of Nodes	8	27	176
N. of Edges	12	82	651
Density	0.0714	0.0199	0.0033
Average node connectivity	0.0714	0.0199	0.0034

Figure 

The number of nodes in the social network of the pharmaceutical industry in Taiwan has tripled over the past 20 years. the result shows pharmaceutical industry in Taiwan is a rapid growth popular industrial area, and more and more scientists are investing in the industry. The network density indicates that the network was very denser in 2001-2007 and looser in 2008-2014 and 2015-2021, with density decreasing overall. This is because it is difficult for collaborative relationships to increase together as the network grows, which also means that the pharmaceutical industry still has a lot of potential for collaboration. The average degree of nodes has increased, indicating that the development of pharmaceuticals has required more people to collaborate due to

increased complexity. This also indicates that the quantity of collaboration relationships is important in pharmaceuticals. After 2001-2007 concentration more and more decreased until 2015-2021 concentration decreased 21 times, indicating the reduced importance of intermediaries in forming collaborative relationships.

It would indicate a significant decrease in the importance of intermediaries in forming collaborative relationships. This could suggest a shift towards more direct collaborations between actors in the pharmaceutical industry in Taiwan, potentially driven by advancements in Taiwan's communication technology and increased opportunities for direct communication and collaboration. However, without further context and analysis, it is difficult to draw definitive conclusions. So, the study use elite interviews to improve the result. The interview data extended the analysis to reveal the perceptions of key actors in the network regarding the development of intermediaries and the institutional environment. The interviewee shows that:

The domestic market in Taiwan is small, so we try to go overseas as much as possible, and our partners also choose overseas companies of similar size to ours.

[(Interview, T4)]

The number of clinical cases in Taiwan is too small, so we are at a disadvantage in collecting cases. Therefore, we will cooperate with overseas companies to conduct clinical case collection simultaneously, so that the data collection will be fast enough.

[(Interview, T14)]

Through the interviews, we learned that Taiwan's pharmaceutical industry is limited by the small domestic market, so the cooperation is usually dominated by overseas companies, which are also used to expand overseas markets.

4.5 Comparative Analysis

Taiwan's advantage in the pharmaceutical sector is attributed to its developed high-tech industries and knowledge and technology transfer between these industries. Despite these efforts, the biotech and pharmaceutical industry's developmental progress in Taiwan is slower than the government's expectations. Thus, more public policies supporting the industry, such as the Production Linked Incentives Scheme in India and the Pharmaceutical Act in Taiwan, need to be considered to transform the industry and sustain global competition. Taiwanese generic drug manufacturers are relatively small and medium-sized enterprises that are struggling with manufacturing. Most of the pharmaceutical manufacturers in Taiwan are small and medium-sized

enterprises, which are purely engaged in product development for the pharmaceutical industry, chemical pharmaceuticals, or clinical trials of pharmaceuticals, and have a small domestic market with relatively high labor costs, which makes the biomedical sectors more suitable for developing knowledge-intensive industrial transformation. As the interviewer said:

The development of Taiwan's biotechnology industry is often not as fast as expected, but the government still invests a lot of effort in this industry, and every major policy will include the biotechnology and medicine industry.

[(Interview, T2)]

Taiwan's pharmaceutical companies will not invest in the initial research and development part, they will buy from intermediaries and then make the finished product, so that the profit will be more quickly

[(Interview, T14)]

The cost of obtaining raw materials (APIs) in India is relatively low and in fact the labor cost for manufacturing is also low, which has led us to be very competitive in the international

[(Interview, I4)]

A validation section in the quality assurance department carries out the validation of areas, processes, equipment and systems. For validations and testings, we usually collaborate or tie up with any organisation or industry to proceed.

[(Interview, I8)]

Academic infrastructure needs to be robust, though institutions are coming it, institutions like NIPER should come up more in numbers and research should be the priority.

[(Interview, I9)]

The study found that both countries have built their networks with international collaborators, mainly based in the US. While the Indian pharmaceutical industry is in its growth phase, there is still a need for building the system, particularly in the innovation space, such as new molecular entities and complex generics. To remain competitive, India needs to expand and consolidate its global outline and collaborate with international regulatory bodies. On the other hand, Taiwan's advantage in the pharmaceutical sector is attributed to its developed high-tech industries and knowledge and technology transfer between these industries. Despite these efforts, the biotech and pharmaceutical industry's developmental progress in Taiwan is slower than the government's expectations. Thus, more public policies supporting the industry,

such as the Production Linked Incentives Scheme in India and the Pharmaceutical Act in Taiwan, need to be considered to transform the industry and sustain global competition.

5. Conclusion

5.1 Development of Taiwanese and Indian pharmaceutical innovation system in the past two decades

From reading the innovation network maps, we found Taiwan and India's pharmaceutical industries have gradually developed over the past 20 years, and each has its own international R&D collaboration partners. Taiwan and India have less opportunity to cooperate in the international network community. Through a thorough examination of the evolution of the pharmaceutical industries, this project examined international relationships between India and Taiwan. This collaborative endeavor provided insight into the technological foresight of the fusion of biotechnology and related emerging technologies. These findings lead to the conclusion that India is unique in the development of generic drugs in the world the main reason is that India has lower labor costs and lower cost of acquiring APIs, while most of the pharmaceutical manufacturers in Taiwan are small and medium-sized enterprises, which are purely engaged in pharmaceutical industry, chemical drug manufacturing, or product development for clinical trials. Regarding innovation systems, it is evident that both India and Taiwan have their strengths and weaknesses. India's generic drug industry is highly competitive and well-established, thanks to its low labor costs and the availability of cheap raw materials. This has allowed Indian companies to produce high-quality generics at significantly lower prices than their Western counterparts. On the other hand, Taiwan's pharmaceutical industry is relatively small, and most companies are focused on research and development rather than manufacturing. However, Taiwan's focus on research and development has led to the development of a robust innovation system that supports the growth of the biotechnology and pharmaceutical sectors. The government has invested heavily in research and development, and a vibrant start-up system has produced many successful companies. In contrast, India's innovation system is not as well-developed, and the government's investment in research and development is relatively low compared to other countries. Overall, it is clear that India and Taiwan have complementary strengths in the pharmaceutical industry, and there is potential for greater collaboration between the two countries. By leveraging India's expertise in generic drug manufacturing and Taiwan's strengths in research and development, both countries can benefit from increased cooperation in the biotechnology and pharmaceutical sectors.

5.2 The interaction between institution and pharmaceutical innovation system

From 2001 to 2021, the pharmaceutical industry in Taiwan has undergone various changes. During the period 2001-2007, the major organizations in Taiwan were BioCryst Pharmaceuticals Inc, Shionogi & Co Ltd, Amarillo Biosciences Inc, CytoPharm, Inc. and National Cheng Kung University. These organizations are primarily engaged in research and development and clinical trials. During 2008-2014, major organizations shifted their focus to research and development of new technologies and manufacturing facilities, including National Health Research Institutes, Zentaris Pharmaceuticals LLC, Sciclone Pharmaceuticals. During the period 2015-2021, Taiwan's major institutions will focus more on innovative research and new technology development, such as Zai Lab Ltd, Zentaris Pharmaceuticals LLC, Medigen Vaccine Biologics Corp, and Development Center for Biotechnology. It can be seen that Taiwan's pharmaceutical industry has shifted from early clinical trials and research and development to more innovation and technology development, which has helped to enhance the competitiveness of Taiwan's pharmaceutical industry.

In India, the Indian pharmaceutical industry has undergone considerable changes from 2001 to 2021. During 2001-2007, the major players in India were Sobha Renaissance Information Technology Pvt Ltd, Sunpa Sobha Software (China), L, ethica Clinical Research Inc. ethicamatrix CRO Pvt., L and Syneos Health NC LLC, which are mainly engaged in clinical trials and research. During the period 2008-2014, major players shifted to manufacturing equipment and healthcare services, including Gilead Sciences Inc, Trivitron Healthcare Pvt Ltd, Sterling Hospitals Ltd and Asilia Home Health. During 2015-2021, India's major players have increased their focus on new technology development and research, such as Gilead Sciences Inc, Cipla Ltd, Glenmark Pharmaceuticals Ltd, Curadev Pharma Pvt Ltd and Macleods Pharmaceuticals Ltd. It is evident that The shift in the Indian pharmaceutical industry from earlier clinical trials and research and development to more focus on IP and innovation, especially in the period 2015-2021, where many of the major players are leaders in developing new drugs or developing new technologies, is an indication that the Indian pharmaceutical industry is continuously moving in the direction of higher value addition.

5.3 Recommendations and future work

Based on the analysis, the following recommendations and future work can enhance collaboration and foster growth in the pharmaceutical sectors of Taiwan and India: Strengthen collaboration and knowledge sharing through partnerships, platforms, and cross-country research consortia. Align policies and regulations on intellectual property rights, drug development,

manufacturing standards, and market access. Increase investment in research and development, supporting early-stage drug discovery and fostering public-private partnerships. Strengthen the innovation system through initiatives, incubators, and collaborations between academia and industry. Invest in skill development and capacity building for professionals in the pharmaceutical sector. Explore international markets and partnerships to expand the reach of pharmaceutical products. Embrace emerging technologies like biotechnology, precision medicine, and digital health to drive innovation. Establish mechanisms for continuous monitoring and evaluation of collaborative efforts. Adaptability to industry trends and ongoing dialogue between stakeholders is crucial for realizing the potential of the pharmaceutical industries in both countries.

5.4 Contributions to Enhancing Collaboration and Fostering Growth

Based on the analysis of the pharmaceutical industry knowledge flow and the interaction between institutions in Taiwan and India, this paper makes several valuable contributions.

Firstly, it provides a comprehensive overview of the development of the pharmaceutical industries in Taiwan and India from 2001 to 2021, highlighting the major players and their shifting focus over time. This historical perspective helps us understand the evolution and transformation of the industries in both countries. Secondly, the paper examines the interaction between institutions and the pharmaceutical innovation system in Taiwan and India. It identifies the strengths and weaknesses of each country's innovation system and emphasizes the complementary nature of their pharmaceutical industries.

Furthermore, the paper offers practical recommendations for enhancing collaboration and fostering growth in the pharmaceutical sectors of Taiwan and India. These recommendations include collaboration and knowledge sharing, policy and regulatory alignment, research and development investment, strengthening innovation, skill development and capacity building, market expansion, international partnerships, embracing emerging technologies, and continuous monitoring and evaluation.

By providing these recommendations, the paper aims to contribute to the ongoing dialogue and efforts to strengthen the pharmaceutical industries in Taiwan and India. It highlights the importance of collaboration, policy alignment, investment in innovation, and skill development for the sustainable growth and competitiveness of the pharmaceutical sectors in both countries.

Overall, this paper offers valuable insights and actionable recommendations that can guide policymakers, industry stakeholders, and researchers in their endeavors to foster collaboration, drive innovation, and achieve mutual growth in the pharmaceutical industries of Taiwan and India.

Reference

- ADAMS, M. J., KANE, P. E. & LIPA, M. 2022. Exploring Pathways from Data to Knowledge to Insights in the Pharmaceutical Industry: 'Introducing the Pharmaceutical Knowledge Ecosystem'. Level 3, 16, 1.
- AKHTAR, G. 2013. Indian pharmaceutical industry: an overview. *IOSR journal of Humanities and Social Science*, 13, 51-66.
- ALBUQUERQUE, E. D. M. E. 2022. National systems of innovation and Non-OECD countries: notes about a rudimentary and tentative "typology". *Brazilian Journal of Political Economy*, 19, 602-620.
- BARTHOLOMEW, S. 1997. National systems of biotechnology innovation: complex interdependence in the global system. *Journal of international business studies*, 28, 241-266.
- BERGEK, A., JACOBSSON, S., CARLSSON, B., LINDMARK, S. & RICKNE, A. Analysing the dynamics and functionality of sectoral innovation systems. A Manual, in 10 Year Anniversary DRUID Summer Conference, Copenhagen, 2006. 27-29.
- BERGEK, A., JACOBSSON, S., CARLSSON, B., LINDMARK, S. & RICKNE, A. 2008. Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research policy*, 37, 407-429.
- BIANCHI, M., CAVALIERE, A., CHIARONI, D., FRATTINI, F. & CHIESA, V. 2011. Organisational modes for Open Innovation in the bio-pharmaceutical industry: An exploratory analysis. *Technovation*, 31, 22-33.
- BJERKE, L. 2022. Antibiotic geographies and access to medicines: Tracing the role of India's pharmaceutical industry in global trade. *Social Science & Medicine*, 312, 115386.
- BOGERS, M., ZOBEL, A.-K., AFUAH, A., ALMIRALL, E., BRUNSWICKER, S., DAHLANDER, L., FREDERIKSEN, L., GAWER, A., GRUBER, M. & HAEFLIGER, S. 2017. The open innovation research landscape: Established perspectives and emerging themes across different levels of analysis. *Industry and Innovation*, 24, 8-40.
- BRAUN, A., MUELLER, E., ADELHELM, S. & VLADOVA, G. 2012. Knowledge flow at the fuzzy front-end of inter-firm R&D collaborations—insights into SMEs in the pharmaceutical industry. *International Journal of Entrepreneurship and Innovation Management*, 15, 29-46.
- CARLSSON, B., JACOBSSON, S., HOLMÉN, M. & RICKNE, A. 2002. Innovation systems: analytical and methodological issues. *Research Policy*, 31, 233-245.
- CHATURVEDI, S. 2005. Evolving a national system of biotechnology innovation: some evidence from Singapore. *Science, Technology and Society*, 10, 105-127.
- CHEN, H., MEHRA, A., TASSELLI, S. & BORGATTI, S. P. 2022. Network dynamics and organizations: A review and research agenda. *Journal of Management*, 48, 1602-1660.
- CHEN, S.-H. 2014. Knowledge Transfer and Innovation Networks in the Taiwanese Biopharmaceutical Innovation System. University of Nottingham.

- COOK, K. S. & WHITMEYER, J. M. 1992. Two approaches to social structure: Exchange theory and network analysis. *Annual review of Sociology*, 18, 109-127.
- COOKE, P. 2001. Regional innovation systems, clusters, and the knowledge economy. *Industrial and corporate change*, 10, 945-974.
- CRONIN, E., FIELDSEND, A., ROGGE, E. & BLOCK, T. 2022. Multi-actor Horizon 2020 projects in agriculture, forestry and related sectors: A Multi-level Innovation System framework (MINOS) for identifying multi-level system failures. *Agricultural Systems*, 196, 103349.
- DAHESH, M. B., TABARSA, G., ZANDIEH, M. & HAMIDIZADEH, M. 2020. Reviewing the intellectual structure and evolution of the innovation systems approach: A social network analysis. *Technology in Society*, 63, 101399.
- DAI, X., FANG, X., HOU, X., MIAO, Q., QIU, T., SUN, M., PENG, X., XU, Y., YU, K. & WU, P. 2022. Development of biomedical industry and its market status and trend. *AIP Conference Proceedings*, 2511.
- DEN HERTOOG, P. & BILDERBEEK, R. 2019. The new knowledge infrastructure: the role of technology- based knowledge-intensive business services in national innovation systems. *Services and the knowledge-based economy*. Routledge.
- DRUCKER, P. 2014. *Innovation and entrepreneurship*, Routledge.
- FABER, A. & HOPPE, T. 2013. Co-constructing a sustainable built environment in the Netherlands— Dynamics and opportunities in an environmental sectoral innovation system. *Energy Policy*, 52, 628-638.
- FIELKE, S. J., GARRARD, R., JAKKU, E., FLEMING, A., WISEMAN, L. & TAYLOR, B. M. 2019. Conceptualising the DAIS: Implications of the 'Digitalisation of Agricultural Innovation Systems' on technology and policy at multiple levels. *NJAS-Wageningen Journal of Life Sciences*, 90, 100296.
- FREEMAN, C. 1995. The 'National System of Innovation' in historical perspective. *Cambridge Journal of economics*, 19, 5-24.
- GASSMANN, O., ENKEL, E. & CHESBROUGH, H. 2010. The future of open innovation. *R&d Management*, 40, 213-221.
- HOWELLS, J. 1999. Research and Technology Outsourcing and Innovation Systems: an Exploratory Analysis. *Industry and Innovation*, 6, 111-129.
- HSIAO, W. W.-W., LIN, J.-C., FAN, C.-T. & CHEN, S. S.-S. 2022. Precision health in Taiwan: A data- driven diagnostic platform for the future of disease prevention. *Computational and Structural Biotechnology Journal*, 20, 1593-1602.
- JOHAN, H. 2019. Dynamic innovation systems: what is the role of services? *Services and the Knowledge- based Economy*. Routledge.
- KLERKX, L. & BEGEMANN, S. 2020. Supporting food systems transformation: The what, why, who, where and how of mission-oriented agricultural innovation systems. *Agricultural Systems*, 184, 102901.
- KOASIDIS, K., NIKAS, A., NEOFYTOS, H., KARAMANEAS, A., GAMBHIR, A., WACHSMUTH, J. & DOUKAS, H. 2020. The UK and German low-carbon

- industry transitions from a sectoral innovation and system failures perspective. *Energies*, 13, 4994.
- LEE, P.-C., WANG, J. T.-H., CHEN, T.-Y. & PENG, C.-H. 2022. *Digital Health Care in Taiwan: Innovations of National Health Insurance*, Springer Nature.
- LI, Y., WEI, Y., LI, Y., LEI, Z. & CERIANI, A. 2022. Connecting emerging industry and regional innovation system: Linkages, effect and paradigm in China. *Technovation*, 111, 102388.
- LIU, W.-H., LEE, H.-C., SUNG, W.-Y. & YANG, T.-Y. 2022. The roles of Taiwanese universities in coastal revitalization: A study of two case projects. *Marine Policy*, 139, 105050.
- LUNDVALL, B.-Å. 1999. National business systems and national systems of innovation. *International Studies of Management & Organization*, 29, 60-77.
- MALERBA, F. 2002. Sectoral systems of innovation and production. *Research policy*, 31, 247-264.
- MALERBA, F. & NELSON, R. 2011. Learning and catching up in different sectoral systems: evidence from six industries. *Industrial and Corporate Change*, 20, 1645-1675.
- MARKARD, J. 2020. The life cycle of technological innovation systems. *Technological forecasting and social change*, 153, 119407.
- MEHRALIAN, G., RASEKH, H. R., AKHAVAN, P. & GHATARI, A. R. 2013. Prioritization of intellectual capital indicators in knowledge-based industries: Evidence from pharmaceutical industry. *International Journal of Information Management*, 33, 209-216.
- MORGA, A., LATIMER, N. R., SCOTT, M., HAWKINS, N., SCHLICHTING, M. & WANG, J. 2023. Is Intention to Treat Still the Gold Standard or Should Health Technology Assessment Agencies Embrace a Broader Estimands Framework?: Insights and Perspectives From the National Institute for Health and Care Excellence and Institut für Qualität und Wirtschaftlichkeit im Gesundheitswesen on the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use E9 (R1) Addendum. *Value in Health*, 26, 234-242.
- NELSON, R. R. 1993. *National innovation systems: a comparative analysis*, Oxford University Press on Demand.
- NELSON, R. R. & NELSON, K. 2002. Technology, institutions, and innovation systems. *Research Policy*, 31, 265-272.
- QURESHI, A. M. A. & EVANS, N. 2015. Deterrents to knowledge-sharing in the pharmaceutical industry: a case study. *Journal of Knowledge Management*.
- SHEN, W. X., ZENG, X., ZHU, F., WANG, Y. L., QIN, C., TAN, Y., JIANG, Y. Y. & CHEN, Y. Z. 2021. Out-of-the-box deep learning prediction of pharmaceutical properties by broadly learned knowledge-based molecular representations. *Nature Machine Intelligence*, 3, 334-343.
- WATERFIELD, J. 2010. Is pharmacy a knowledge-based profession? *American Journal of Pharmaceutical Education*, 74.

- WONG, C.-Y. 2022. Post Industrial Catch-Up Public Research Institutions: The Cases of ITRI of Taiwan and KIST of Korea. *Experimental Learning, Inclusive Growth and Industrialised Economies in Asia: Lessons from South Korea and Taiwan*. Springer.
- WU, F.-S., WU, C.-H. & TAO, T.-W. 2022. Transformation into New Drug Companies: The Perspective of Dynamic Capabilities. *The Routledge Companion to Technology Management*. Routledge.
- YIGITCANLAR, T., CORCHADO, J. M., MEHMOOD, R., LI, R. Y. M., MOSSBERGER, K. & DESOUZA, K. 2021. Responsible Urban Innovation with Local Government Artificial Intelligence (AI): A Conceptual Framework and Research Agenda. *Journal of Open Innovation: Technology, Market, and Complexity*, 7, 71.

Building Medical Device Innovation System in Taiwan and India (2001-2021)

Shih-Hsin Chen, Wen-Hsin Chi, Hung-Chi Chang
National Yang Ming Chiao Tung University, Taiwan

Abstract

The medical device industry is a rapidly growing sector with great potential to improve healthcare outcomes worldwide. In recent years, both Taiwan and India have been focusing on building their medical device innovation systems to enhance their competitiveness in this sector. This paper presents a comparative analysis of the medical device innovation systems in Taiwan and India. It examines the key factors contributing to their success and the challenges faced in their implementation. The analysis was conducted through a literature review and case studies of companies and organizations involved in the medical device industry in both countries. The results show that Taiwan and India have taken different approaches in building their innovation systems, with Taiwan focusing on the development of high-tech medical devices and India on low-cost medical devices. In Taiwan, the government has played a significant role in promoting the development of the medical device industry by investing in research and development, providing funding for start-ups, and establishing regulatory frameworks. Taiwan has also developed strong partnerships between academia and industry to facilitate technology transfer and commercialization. In India, the government has also supported the medical device industry through initiatives such as the "Make in India" campaign and the establishment of the Medical Devices Park in Andhra Pradesh. India has also implemented regulatory reforms to streamline the approval process for medical devices and has focused on building partnerships with international companies and organizations to promote technology transfer. Taiwan and India face challenges in building their medical device innovation systems, such as the shortage of skilled personnel, insufficient funding, and regulatory barriers. However, they have made significant progress in overcoming these challenges and have shown great potential for continued growth in the medical device industry. Overall, this paper provides insights into the strategies and initiatives that Taiwan and India have implemented to build their medical device innovation

systems and offers recommendations for policymakers and industry leaders to further enhance their competitiveness in the global medical device market.

Keywords: Medical device industry, Innovation system, Taiwan, India, Policy recommendations

1. Introduction

Taiwan's medical equipment industry is a capital-intensive and technology-intensive industry, which is categorized according to its functions and uses into diagnostic and monitoring medical devices, surgical and therapeutic medical devices, assistive and compensatory medical devices, in vitro diagnostic medical devices, other medical devices, as well as preventive and health-promoting equipment. The medical equipment industry is an interdisciplinary technology industry that integrates biomedicine, electronics and electrical engineering, semiconductors, information technology, software, optics/precision instruments, chemistry, materials, and machinery. Due to the wide range of technologies and application areas involved, it exhibits the characteristics of a diversified industry with small-scale production.

However, Taiwan's medical device industry has significant transformation in the recent 12 years. With the biopharmaceutical industry as its core and the support of the medical and information communication technology (ICT) industries, Taiwan integrates cross-departmental government resources through measures such as regulatory easing, startup incubation, and international talent cultivation. By adopting digital technologies such as artificial intelligence (AI), the Internet of Things (IoT), and 5G, and promoting interdisciplinary technological cooperation, Taiwan aims to establish a healthcare data infrastructure and develop cutting-edge technologies to promote innovation and transformation in the medical equipment industry. The medical device industry is the fastest growing sector of Taiwan's biotech industry, with the huge global market demand bringing opportunities for many cross-industry manufacturers to enter the medical device field. However, the medical industry is heavily regulated in all countries, and the differences in medical or insurance systems between countries make it even more difficult for the medical device industry to internationalize. Therefore, one of the goals of this study is to explore how Taiwan's medical device industry can undergo industrial transformation and innovation, and identify its key success factors.

On the other hand, the enforcement of GMP regulations offer the government and industry an international compatible regulatory ecosystem to increase the safety, effectiveness, and quality of medical devices made in Taiwan. Medical device manufacturers in Taiwan have developed advanced production technology in medical device products. However, until today, a very small number of studies have examined the innovation ecosystem holistically. While many studies consider innovation networks as the entire innovation system, a relatively small number of the literature takes the elements of the ecosystem such as institutions, social norms, regulations, and policies into consideration. This study attempts to bridge these gaps through an empirical comparative study of the innovation ecosystem development in the medical device industries in Taiwan.

In India, Drugs, vaccines, and medical devices constitute the industry pillars of futuristic healthcare technology systems(Kale & Wield, 2019). India is self-sufficient in pharmaceutical drugs. In sharp contrast, when it comes to medical devices, it heavily relies on imports. Over 75% of medical devices and diagnostics of India are imported (Datta et al., 2013). Research studies also showed in India many medical devices were either not user friendly or had little or no use vis-à-vis the demand. (Mahal & Karan, 2009; Mahal et al., 2006). By 2020, It was estimated that the world medical devices market would grow from USD 3.7 billion (2014) to USD 520 billion. The Indian medical devices market figures in the top twenty globally by market size and fourth in Asia. India has the lowest per capita spend (USD 3) on medical devices in BRIC countries, which is way behind the developed economies like the USA. This clearly indicates a huge growth potential of medical devices in India.

In addition, there is also huge concern about the quality of medical devices that is dependent heavily on regulations. Regulatory reforms are imminent for Indian manufacturers of medical devices and foreign multinational companies that aim to enter and expand their business in India(Radhadevi et al., 2012). It is imperative to build an innovative ecosystem around the medical devices industry as it would strengthen capacity and interdisciplinary work culture of the national device regulatory body, institutionalized health care payers, medical councils, and associations. Continuous medical education and national medical guidelines for medical practitioners would facilitate market access for innovative products(Jaroslawski et al., 2013).

Therefore, this research aims to analyze the impact of technology policies, industry environment construction, and innovation ecosystem formation on the development and transformation of Taiwan's and India's medical device industry over the past 20 years through empirical analysis, and to understand how technology governance decisions can promote industry development. Based on the background and purpose of this study, the following questions are proposed:

- (1) How has the Taiwanese and Indian medical device innovation system developed in the past two decades?
- (2) How do institutional factors impact the evolution of the innovation system in the process of technological development?

2. Literature Review

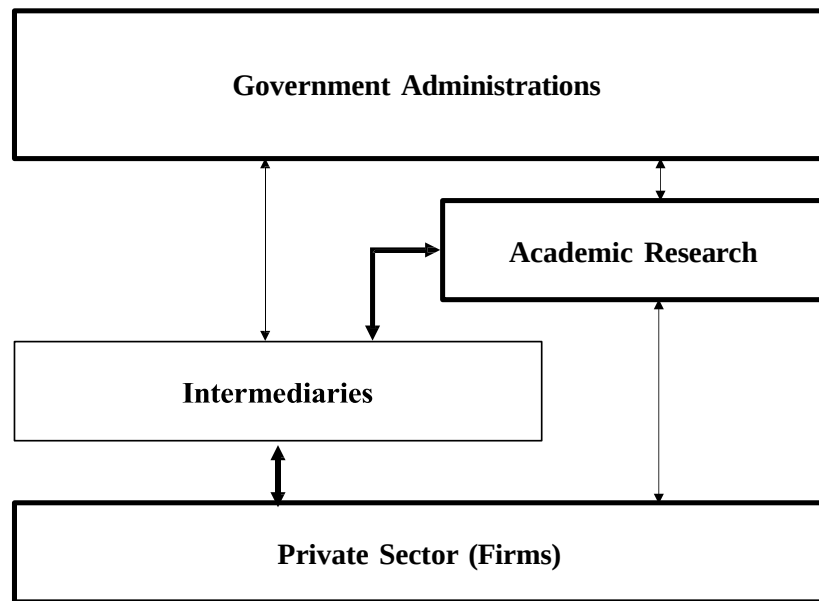
As emerging technologies develop rapidly, the definitions, scope, applications, and technology governance approaches also develop rapidly. In this session, we will review the development of medical device industries, the evolution of institution settings, and the policy context of India and Taiwan.

2.1 Innovation System and Actors

Innovation is widely recognized as a social process, involving the networking of actors, and is driven by relationships, learning, knowledge, and collaboration (Bergek et al., 2008; Cooke, 2001; Cooke et al., 1997; Freeman, 1991; Freeman, 1995; Jensen et al., 2007; Lundvall, 1992; Malerba, 2002; Nelson, 1993). The collaboration often involves research organizations, regulators, capital providers, customers, clients, and research institutions (Cleland & Manley, 2007).

There are various types of innovation systems (Edquist & Chaminade, 2006) including national innovation systems (Edquist & Chaminade, 2006), regional innovation systems (Cooke et al., 1997) and sectoral innovation systems (Malerba, 2002). National innovation systems refer to the set of institutions and actors within a nation-state that interact to produce, diffuse and utilize innovations. Regional innovation systems focus on the interactions between actors within a specific geographical region to produce and utilize innovations, while sectoral innovation systems focus on the interactions between actors within a specific industry or sector to produce and utilize innovations.

Sectoral innovation system comprises a knowledge base, basic technologies, institutions related to a technology, actors and networks (Malerba, 2002, 2005; Malerba & Montobbio, 2003). Exploring the interactions among the various actors provides a means of a better understanding on the changing dynamics of the innovation system and allows the identification of appropriate recommendations for improvements in future policy (Agrawal, 2001; Wield et al., 2013; Zucker et al., 2000). Mani (2006) mapped out the sectoral system of innovation in India's pharmaceutical industry through discussions of relationships between actors. This study refers to this framework and integrates the characteristics of the medical equipment industry to identify key actors.



Source: The Authors, based on Mani (2006) and Chen et al. (2016)

Figure 1 The Key Actors in Sectoral Innovation System

The medical device industry is regulated and promoted through a cooperative relationship between institutions and actors. Government Administrations are responsible for regulating the industry and providing funding for research and development. Academic Research institutions conduct R&D and collaborate with government agencies, intermediaries, and firms. Intermediaries provide support and facilitate collaboration between different actors in the industry. Private Sector (Firms) are the primary actors in the industry, developing, producing, and selling medical devices. They rely on support from other actors to comply with regulations and access resources. Cooperation and collaboration among these actors are crucial in promoting industry development while ensuring patient safety.

2.2 Medical Device Innovation System in Taiwan

Medical device manufacturers in Taiwan have developed advanced production technology in medical device products. They have secured a dominant position in the world by providing of self- owned brands to MNC Companies. Contact lenses and glucose meters are potential export- oriented medical devices from Taiwan. Taiwan's manufacturers can proficiently manage flexible manufacturing and process cost management. They come across as a competitive lot in emerging markets that scout for good quality at reasonable prices, driving their export momentum. MNCs are competing to establish their R & D canters in China. Taiwan's medical device manufacturers are actively investing in the industry, facilitating their role in the International medical device supply chain(Chang, 2012).

Medical Device GMP Regulation has been pioneered by Taiwan in Asia. The Ministry of Health and Welfare in 2010, revised medical device regulations in 1998 for the establishment of a risk-based regulatory system that classifies medical devices into three classes according to their risk. The revised regulations (2005) offer the government and industry an international compatible regulatory ecosystem to increase the safety, effectiveness, and quality of medical devices made in Taiwan.

Research study suggests that the local medical device's transformation is due to the industry implementation of GMP regulation facilities. GMP regulation standards supported the development of local industry as stated by few analysts. GMP regulation-compliant SMEs will be competitive in both local and world markets.

Pharmaceutical Affairs Act regulates medical devices in Taiwan. As per the act, for ease of managing the Medical Devices industry, they are divided into 3 classes (class 1, 2, or 3) and 17 categories based on their levels of risk and characteristics. To further align with international regulatory authorities, The Taiwan Food and Drug Administration (TFDA) of the Ministry of Health and Welfare, the competent health authority for medical devices in Taiwan, regularly reviews global market regulations and revises the guidelines accordingly (Chen et al., 2018).

2.3 India's Medical Device Industry

India is self-sufficient in pharmaceutical drugs. In sharp contrast, when it comes to medical devices, it heavily relies on imports. Over 75% of medical devices and diagnostics of India are imported. There is also huge concern about the quality of medical devices that is dependent heavily on regulations. Regulatory reforms are imminent for Indian manufacturers of medical devices and foreign multinational companies that aim to enter and expand their business in India. (Radhadevi et al., 2012). It is imperative to build an innovative ecosystem around the medical devices industry as it would strengthen capacity and interdisciplinary work culture of the national device regulatory body, institutionalized health care payers, medical councils, and associations. Continuous medical education and national medical guidelines for medical practitioners would facilitate market access for innovative products (Jarosławski & Saberwal, 2013).

It was observed that patent application filings in the medical device sector during the last 5 years (2009–2013) contributed only to 2% of the total patent applications filed, which may be attributed to the nascent medical device sector and lack of Intellectual Property (IP) awareness or funding support for IP filings. The analysis shows increasing trends in medical device patent applications in India, with major share of patent applications being filed from the USA. The Indian applications in this sector contributed only to 17% of the total patent

application filings in the last decade. Although foreign players dominate the medical device sector, this study indicates that though at a small scale, Indian applicants are actively filing patents in all key domains of the medical device sector. With the enabling environment being provided by the Government of India with recent policy initiatives such as Startup India, Make in India, 100% Foreign Direct Investment (FDI), and so on and support to startups for IP filings, the Indian medical device industry is expected to witness aggressive IP filing and innovation trends and is poised to grow exponentially targeting US\$50 billion industry by 2025(Markan & Verma, 2017).

Medical devices industry includes multiple products, from medical instruments to implants it covers a wide range of products. Products also include therapeutic devices to highly modified computerized medical technologies and diagnostics. A well-developed ecosystem and innovative cycle are observed in the development of most Hitech innovative products and technologies. India needs such an innovative ecosystem in the medical devices industry to promote both the local industries and to foster international collaborations for sustained competitive advantage. This innovative ecosystem should reduce the excessive dependency on imports(Jaroslowski & Saberwal, 2013). The development of most hi-tech novel products and technology has been often supported by a well-developed ecosystem (Dang, 2019). India needs such new models to be developed for promoting local indigenous enterprises and self-sufficiency. These initiatives will reduce dependency on imports and improve the fiscal scenario of our country(Jaroslowski & Saberwal, 2013). There are huge challenges like pricing caps levied by the government for companies in India's medical devices sector.

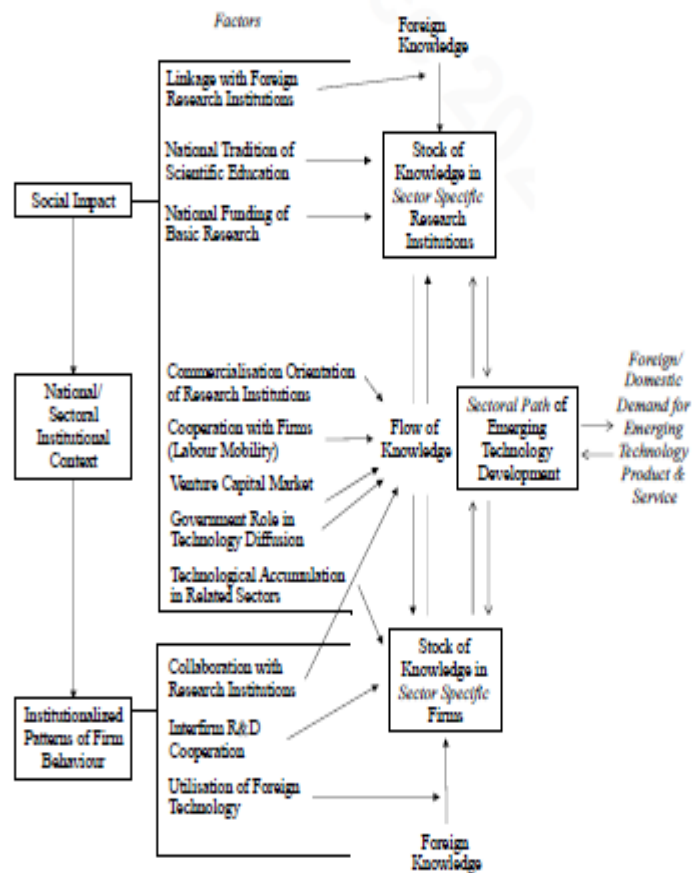
Mundane tasks like "rectification of erroneous declaration on the label" have to be routed through multiple regulatory bodies, taking exercise. The manufacturers and importers of medical devices are restricted from promoting their products to the customers due to the legal framework in place. The medical device industry's penetration is growing due to increasing awareness in the population on early detection, prevention of diseases, and medical tourism. The future action for India is to revisit and promote their traditional business and standards. There is a felt need to invest in futuristic technologies for the benefit of patients. There is need to evaluate the value chains of medical device sector. Repositioning the sector would help to improve the competitive landscape. (Deloitte & NATHEALTH, 2016)

Current regulatory system is not vivid, and lacks transparency. Due to lack of technology, the industry is heavily dependent on imports. It was estimated that the medical devices market would grow at ~15% to USD 8.6 billion by 2020. Industry estimates indicated a huge growth potential at ~28% to USD 50 billion by 2025. Consumables and implants, diagnostic imaging, instruments & appliances, patient aids, and others are the four Indian medical devices

industry segments. Both domestic and MNC players are operating in this sector. Indian states like Maharashtra and Tamil Nadu are setting the example of establishing holistic ecosystem to foster the indigenous medical devices industry. R&D centers designing innovative indigenous products, have been established in cities of Bangalore, Mumbai and Chennai. Tax incentives are boosting the growth of medical devices industry.

2.4 Analytical Framework

A systemic approach is most suitable for analyzing innovations as they are the collective achievement resulting from interactions between various actors (Van de Ven, 2008). According to Bartholomew's national biotechnology innovation system framework, biotechnology innovation results from accumulating scientific knowledge between firms and research institutions rather than knowledge diffusion between firms (Bartholomew, 1997). However, the sectoral innovation system concept differs from the regional and national innovation system approach, as it encompasses structures and processes that are not limited to spatial scales, avoids conceptual biases towards regional or national interactions, and can be better able to define the scope and structure of the industry (Bunnell & Coe, 2001; Cheong et al., 2020; Weigel, 2011). Chaturvedi (2005) adapted Bartholomew's framework to analyze the biotechnology innovation system in Singapore and supplemented the idea of a sectoral path of biotechnology development to emphasize linkages with foreign research institutions, policy support, and system demand. This enhanced framework can capture the influence of international connections on knowledge flow. Therefore, the sectoral innovation system is adopted as the main framework (Chen et al., 2016), which is combined with Bartholomew's framework of the National Biotechnology Innovation System (Bartholomew, 1997) and Chaturvedi's framework of the Biotechnology Innovation System (Chaturvedi, 2005) to comprehensively build the medical device innovation systems in Taiwan and India. Relevant factors such as knowledge and technology, institutions, actors, and networks are considered in this framework (Figure 2).



Source: The Authors, based on Bartholomew (1997), Chaturvedi (2005) and Chen et al. (2016)

Figure 2 Analytical Framework

3. Methodology

3.1 Research Design

The study employs a mixed-method approach, combining social network analysis, and elite interviews. Through social network analysis, this research hopes to know how the network of medical device industry changes over time, further explore the insights of building innovation systems from the context of medical device industries, and study the emergence of emerging technological innovation systems. Qualitative methods will be mainly used to provide insightful explanations; however, these will be supplemented by quantitative analysis of industry structure and the scientific base for developing medical device industries in Taiwan and India. In the meantime, extensive elite interviews will be conducted to explore the factors associated with building innovation systems and the industrial transformation process.

3.2 Data collection

The data collection process in this research involves two methods: social network analysis and elite interviews. Social network analysis measures and maps relationships and flows between various entities, while elite interviews gather information about the factors associated with building innovation systems and the industrial transformation process from industry experts. The social network analysis will use 20 years of industry data from MarketLine database, while the thematic analysis will be applied to analyze interview transcripts.

3.2.1 Social network analysis

The process of social network analysis involves the measurement and mapping of relationships and flows between various entities such as people, groups, organizations, animals, computers, or other information processing entities. In this analysis, the individuals and groups are represented as nodes, and the relationships or flows between them are depicted as links. Through this approach, social network analysis offers both visual and mathematical insights into human relationships (Jamali & Abolhassani, 2006). Modern social network analysis comprises four defining features, which include:

(1) the utilization of ties linking social actors as a structural intuition, (2) grounding in systematic empirical data, (3) heavy reliance on graphic imagery, and (4) the utilization of mathematical and/or computational models (Freeman, 2004).

In this research, we are trying to know how the network of Taiwan's medical device industry change over the time through social network analysis. The secondary data collection began with collecting the industry data from the MarketLine database. In this study, we collect 20 years (2001- 2021) of data. A list of 595 instances of deals involving 429 deals in India and 166 deals in Taiwan.

3.2.2 Elite interviews

Qualitative research is geared toward exploration, discovery, and generalization; it adopts a macro perspective, emphasizing the relationship and understanding between the researcher and the respondent. It discusses different topics as individual cases, is highly sensitive to the overall social structure, remains emotionally neutral, and is relatively flexible in its overall research design (Patton, 1990). Elite interviews are one of the common methods of data collection in qualitative research. This method is used to understand respondents' thoughts on the research questions or to discuss various perspectives based on their personal experiences. In this research, elite interview will focus on gathering information regarding the factors

associated with building innovation systems and the industrial transformation process. The main drivers for forming international collaboration and the role of an innovation system in medical device industries in Taiwan will be further explored through information gathered from elite interviews, including firms, policymakers, think tank researchers, and other research organizations. The interviewees will be asked about their experience of being an actor in the process of constructing innovation system. For instance, how to manage and facilitate innovation and system development, what institutional factors affected the formation of innovation system, what policy change influenced their choices of development strategies, what level of each collaboration scale was, and what barriers they faced while commercialize their innovation products. In addition, theme analysis is a method that systematically recognizes, organizes, and provides insights into the patterns of meaning (themes) within a dataset, enabling researchers to see and make sense of collective or shared meanings and experiences across the data (Braun & Clarke, 2012). In this research, thematic analysis will be applied to analyze interview transcripts for 11 interviews in Taiwan and 10 interviews in India.

3.3 Data analysis

Data analysis is the process of examining and interpreting data in order to gain insights and draw conclusions about a particular research topic. In this study, both quantitative and qualitative data analysis methods will be used to analyze the collected data. Social network analysis will be used to analyze the structure and dynamics of the medical device industry in Taiwan over a period of 20 years. The elite interview data will be analyzed thematically to identify patterns and themes related to the factors associated with building innovation systems and the industrial transformation process. Finally, the results of both data analyses will be synthesized to provide a comprehensive understanding of the innovation system in the medical device industry in Taiwan, including its drivers, barriers, and potential for international collaboration.

3.3.1 Social network analysis

After collecting the data on deals involving the medical device industry in Taiwan from the MarketLine database, we conducted a social network analysis to understand how the network has evolved over the past two decades. First, we constructed a network graph with nodes representing the companies involved in the deals and links representing the relationships between them. To measure the structural properties of the network, we calculated various centrality measures for each node. These measures included degree centrality, which represents the number of direct connections a node has, betweenness centrality, which represents the extent to which a node lies on the shortest path between other nodes, and eigenvector centrality, which represents the importance of a node based on its connections to other high-scoring nodes. We also calculated

network-level metrics such as density, which measures the proportion of actual connections compared to the total number of possible connections, and clustering coefficient, which measures the extent to which nodes tend to cluster together. To understand how the network has changed over time, we calculated these measures for each year in our dataset and visualized the results using line graphs. We also conducted a community detection analysis to identify clusters of companies that tend to be closely connected within the network.

3.3.2 Interviews and Thematic analysis

The elite interviews were analyzed using thematic analysis, which involved identifying, analyzing, and reporting patterns (themes) within the data set (Braun & Clarke, 2012). The process involved several steps: familiarizing with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report (Braun & Clarke, 2012). Firstly, the transcripts of the interviews were read several times to become familiar with the data. Next, initial codes were generated by the primary researcher, which were then discussed and refined by the research team. The codes were then collated and categorized into potential themes, which were further refined through repeated discussion and comparison. The research team then reviewed and defined each theme, and the themes were named to accurately represent the content

The analysis revealed several themes related to the factors associated with building innovation systems and the industrial transformation process in Taiwan's medical device industries. These themes included policy support, talent development, international collaboration, industry-academia linkage, funding and investment, and regulatory environment. Policy support was identified as a critical factor in building innovation systems. Interviewees noted the importance of policies that provide funding, tax incentives, and regulatory support to promote innovation and commercialization. Talent development was also seen as crucial, with interviewees stressing the need for education and training programs that cultivate the skills and knowledge required for innovation. International collaboration emerged as another key theme, with interviewees emphasizing the importance of partnerships with overseas firms and institutions. Industry-academia linkage was also identified as important, with interviewees highlighting the need for universities and research institutions to work closely with industry players to promote innovation. Funding and investment were also highlighted as essential components of building innovation systems, with interviewees noting the importance of government funding and venture capital investment to support early-stage innovation. Finally, the regulatory environment was identified as a critical factor, with interviewees stressing the need for a supportive and flexible regulatory framework that enables innovation while ensuring patient safety.

In summary, the analysis of the elite interviews revealed several key themes related to the factors associated with building innovation systems and the industrial transformation process in Taiwan's medical device industries. These themes provide valuable insights for policymakers and industry players seeking to foster innovation and growth in the sector.

4. Findings and Discussion

4.1 Knowledge Base and Technology Flow of Medical Device Industry in Taiwan and India

The development of medical device industry requires high cooperation between industry, government, academia and research. Therefore, this study takes into account the knowledge base and technology flow of medical device Industry in Taiwan and India from the perspectives of medical device product development, policy environment, and industry clusters.

4.1.1 Knowledge Base and Technology Flow of Medical Device Industry in Taiwan

In 2021, the revenue of Taiwan's biotech industry reached NT\$666.5 billion, and private investment in biotech exceeded NT\$60.895 billion. The revenue of the medical device industry was NT\$236.3 billion, a growth of 22.8% from NT\$192.4 billion in 2020, with an estimated 1,241 manufacturers and approximately 49,916 employees, making it the largest contributor to Taiwan's biotech industry in terms of revenue and job creation. The overall export value of the medical device industry in 2021 was NT\$146.1 billion, a growth of 24.8% from 2020. Due to Taiwan's high quality control capabilities and cost-effectiveness, Taiwanese medical device manufacturers have been an ideal partner for international manufacturers' OEM production. In recent years, Taiwanese manufacturers have been investing in and cultivating their own brands, driving the continuous growth of Taiwan's medical device industry.

Products and R&D Process of Medical Device Industry in Taiwan

According to the definition of the "Medical Device Management Act" released by the Ministry of Health and Welfare, medical devices refer to instruments, apparatus, appliances, materials, software, in vitro diagnostic reagents, and related articles. They are designed and used to achieve the following objectives by means other than pharmacology, immunology, metabolism or chemistry acting on the human body: (1) diagnosis, treatment, relief or direct prevention of human diseases; (2) regulation or improvement of human body structure and function; (3) regulation of fertility. Based on this definition, the scope of medical device products includes medical instruments and equipment and medical consumables. Still, it does not have biological effects such as blood products, serums, fitness equipment, and other products.

Referring to the "Classification and Grading of Medical Devices" announced by the Ministry of Health and Welfare, medical devices are classified according to their "functions" as the primary criteria and "uses" and "structures" as the secondary criteria. They are categorized into diagnostic and monitoring medical devices, surgical and therapeutic medical devices, auxiliary/compensatory medical devices, in vitro diagnostic medical devices, and other medical devices that do not fall under the four categories mentioned above based on their functionalities. With the rise of health consciousness and the promotion of healthcare prevention, the Ministry of Economic Affairs, Bureau of Industrial Development has also included devices and supplies for disease prevention and health promotion within the scope of the medical device industry, by the trend of industry development.

R&D Process of Medical Device Industry in Taiwan

Looking back at the development of medical device R&D and industry in Taiwan, it received government support and assistance early on, primarily focused on producing low-end medical devices, such as catheters, medical gauze, medical gloves, and cotton. Due to the low overall product value-added, Taiwan entered Southeast Asia, Japan, and Europe markets. As Taiwan's medical device production capabilities improved, products became more diverse, but OEM/ODM for overseas manufacturers remained the mainstay. At that time, the main products included various surgical instruments, diagnostic instruments, therapeutic instruments, medical consumables, physical therapy equipment, assistive devices, etc.

However, Taiwan has excellent optomechanical engineering and ICT technology and is competitive in R&D design, precision manufacturing, marketing, and sales. With R&D investment and industry promotion gradually shifting towards the development of mid-range and home-based medical devices products, such as home-use diagnostic equipment like blood glucose monitoring products, blood pressure monitors, and items like contact lenses and mobile aids, many products have already been launched and sold in the global market, occupying a significant market position.

4.1.2 Knowledge Base and Technology Flow of Medical Device Industry in India

The medical devices industry in India is currently valued at USD 11 billion in 2020, and is anticipated to achieve a CAGR of 15.8% to reach USD 50 billion by 2025. India is the fastest growing medical devices market among the emerging economies, with the advantage of allowing foreign direct investment of up to 100% under the automatic route for medical devices manufacturing. The industry includes both large multinationals and SMEs,

which are growing at an unprecedented scale. Of the 750-800 medical device manufacturers in India, 65% of the market is accounted for by domestic manufacturers. According to data from the Ministry of Commerce and Industry in India, the export value of medical devices from India was approximately USD 2.14 billion in 2020, with the largest export markets being the United States, Germany, and the United Kingdom.

Scope and Main Product Categories of India's Medical Device Industry

India is a vast country with a strong regional concept, which makes the sales channel and procurement mode of medical devices in India different depending on the region, and more fragmented and complicated. The profit of each layer is about 12 to 15%. In the import of medical equipment, the Indian government is authorized to conduct global tenders for public and private hospitals, and most government tenders use both technical and commercial tenders, mainly through Indian distributors or subsidiaries of multinational companies.

The product definition of medical equipment in India is based on the regulations of the Medical Devices and Equipment Technology Management Agency of India. According to this agency's definition, medical equipment in India includes various medical devices, instruments, machinery, apparatus, materials, laboratory equipment, and other related products used for the prevention, diagnosis, alleviation, treatment, or correction of diseases, injuries, or disabilities, and for the improvement of the human body's structure or function.

According to Schemes for Promotion of Medical Devices Manufacturing in India, the market size encompasses various segments. Main Product of Medical devices are segregated into four major segments: Cancer care / Radiotherapy, Radiology, Imaging and Nuclear Imaging Devices, Anaesthetics, Cardio-Respiratory and Renal Care, and All Implants. These products include various surgical instruments, imaging equipment, diagnostic reagents, electronic medical equipment, syringes, prosthetics, pacemakers, blood glucose monitors, blood pressure meters, transcutaneous blood oxygen saturation monitors, ventilators, hemodialysis machines, electric stimulators, hearing aids, glasses, and accessories.

R&D Process of Medical Device Industry in India

The Indian medical equipment market relies 75% on imports, while local manufacturers mainly produce low-end medical equipment. The main reason for this is that medical equipment products have lower tariffs, and many multinational corporations have been operating in the Indian market for many years but have not set up production bases in India, instead opting to acquire local manufacturers, establish marketing and logistics operations, and so on. In recent years, the Indian government has been actively promoting the

development of domestically produced medical equipment, including supporting domestic manufacturers in technology innovation and R&D, increasing production capacity, and encouraging foreign companies to establish manufacturing bases in India. With India's aging population and increasing health awareness, the Indian medical equipment market will continue to grow. In addition to traditional medical equipment such as surgical instruments, imaging equipment, and diagnostic reagents, India is also developing emerging areas such as smart medical equipment and telemedicine.

4.1.3 Regulatory Environment and Policy Incentives for Medical Device Industry in Taiwan and India

A supportive regulatory environment and policy incentives are essential for the growth and success of the medical device innovation system. In this section, the changes in the regulatory environment and the direction of incentive policies in both countries since the development of the medical device industry, in order to understand the role of regulatory environment and incentives policies in the process of establishing the medical device innovation system in Taiwan and India.

Regulatory environment for Medical Device Industry in Taiwan and India

Taiwan's medical device industry is regulated by several laws and regulations. The main regulatory body is the Taiwan Food and Drug Administration (TFDA), which oversees the safety and efficacy of medical devices. In terms of medical device regulations, the "Medical Device Management Act" was promulgated to provide the industry with moderate and reasonable buffering and supporting measures to alleviate the impact on the industry. The implementation of this regulation will strengthen Taiwan's medical device lifecycle management system and maintain the safety, efficacy, and quality of medical devices. In addition, the TFDA has also established the "Medical Device Regulatory Consultation and Assistance Center" to provide regulatory consultations and services for domestic medical device manufacturers, and to accelerate the product development process.

India's medical device industry is regulated by the Central Drugs Standard Control Organization (CDSCO) under the Ministry of Health and Family Welfare. The regulatory framework for medical devices in India is governed by the Drugs and Cosmetics Act, 1940, Medical Devices Rules, 2017 and the Medical Devices Rules (Amendment), 2020. These rules cover various aspects of device related regulations, including classification, registration, manufacturing and import, labeling, sales, and post market requirements, etc. Under this framework, medical devices are classified into four categories based on their level of risk, and registration with the CDSCO is mandatory for all devices.

Policy Incentives for Medical Device Industry in Taiwan and India

There are various government-led programs related to promoting the biotech industry in Taiwan and India. With the collaboration of relevant government agencies, Taiwan's biotech industry has continued to grow in overall revenue, and there have been concrete achievements in talent and startup team cultivation, innovation cluster construction, and database integration. To promote the growth of the medical device industry in India, the Indian government has implemented several policy incentives and initiatives. One such initiative is the 'Make in India' campaign, which aims to encourage domestic manufacturing of medical devices and reduce the dependence on imports. The government has also established the National Medical Device Promotion Council to provide a conducive environment for the development of the medical device industry in the country. The government has also implemented the 'National Biopharma Mission' to support the development of medical devices and diagnostics. Additionally, the government has introduced the 'Scheme for Promotion of Medical Device Parks' to set up common infrastructure facilities for the medical device industry, thereby reducing the cost of manufacturing and promoting innovation. Here are several major policy incentives listed below:

Year	Taiwan	India	Goals
1984	Strengthening Biotechnology Industry Promotion Plan		To promote the development of Taiwan's biotechnology industry by providing support for research and development, technology transfer, and human resource development
2002	Challenge 2008: National Development Key Project		To establish Taiwan as a global leader in biotechnology by investing in research and development, infrastructure, and industry-academia collaboration
2007	Act For the Development Of Biotech And New Pharmaceuticals Industry		To transform innovative research and development in the biotech industry into commercial products, and to advance towards the development of high-value-added biopharmaceutical products.

		First National Biotechnology Development Strategy	To integrate the efforts and prepare a holistic vision and a roadmap for Indian biotechnology.
2009	Taiwan Bio-Industry Takeoff Diamond Action Plan		Strengthening industry value chain through industrial R&D, establishing biotech venture capital fund, promoting integrated incubation mechanism, and setting up Food and Drug Administration to establish a regulatory environment for pharmaceuticals aligned with international standards
2013	Taiwan Biotech Industry Takeoff Action Plan		To further enhance Taiwan's biotechnology industry competitiveness by providing financial and regulatory support for the development of innovative medical devices, fostering industry-academia partnerships, and promoting international cooperation
2014		Make in India	To encourage domestic manufacturing of medical devices and reduce the dependence on imports
	Taiwan Bioeconomy Industry Development Plan		To promote the development of Taiwan's bio-economy industry by leveraging Taiwan's strengths in biotechnology and innovation to create new value-added products and services.
2015		The National Biotechnology Development Strategy-2015-	To establish India as a world leader in biotechnology research and development by promoting the use of biotechnology to improve the

		2020(Strategy-II)	quality of life for the people of India.
2015	Taiwan Bioeconomy Industry Development Plan		To promote the development of Taiwan's bio-economy industry by leveraging Taiwan's strengths in biotechnology and innovation to create new value-added products and services.
	5+2 Industrial Innovation Plan		To transform Taiwan's economy by promoting innovation and developing new industries
2016	Biomedical Industry Innovation Promotion Plan		To promote the development of Taiwan's biomedical industry by investing in research and development, fostering industry-academia collaboration, and promoting regulatory reforms to accelerate product commercialization
2017	Act For the Development Of Biotech And New Pharmaceuticals Industry(Amendment)		Expand the scope of high-risk medical device classification to encourage manufacturers to invest in high-risk medical device R&D, and also include "emerging biopharmaceutical products" in the scope of the regulations
		National Biopharma Mission	an industry-academia collaborative mission for accelerating biopharmaceutical development in the country.

2017		Innovate in India (i3) programme	To promote entrepreneurship and indigenous manufacturing in the biopharma sector.
2020		Production Linked Incentive Scheme (PLI)	To incentivize large-scale manufacturing and to build required infrastructure for developing manufacturing clusters
2020		Promotion of Medical Devices Parks Scheme	To set up common infrastructure facilities for the medical device industry, thereby reducing the cost of manufacturing and promoting innovation
2021	Act for the Development of Biotech and Pharmaceutical Industry		Expanding the scope of incentives, encouraging advanced medical care and cross-disciplinary collaboration, promoting both research and development and manufacturing, attracting private sector investment, strengthening talent cultivation, improving the review system, all of which can promote the development and market access of various biopharmaceutical products
	Six core strategic industries to transform Taiwan		By constructing gene and health insurance big data platforms, developing precision prevention, diagnosis, and treatment care systems, as well as creating precision epidemic prevention products and expanding international biomedical business opportunities

		The National Biotechnology Development Strategy-2021-2025(Strategy-III)	To make India globally competitive in biotechnology research, innovation, translation, entrepreneurship and industrial growth and be a USD 150 billion Bioeconomy by 2025

Overall, the Indian government is actively promoting the development of the local medical device industry through a series of regulations and incentives, and hopes to further enhance the competitiveness of Indian medical device products in the international market by improving product quality and technological innovation.

4.2 Institutions and Actors of Medical Device Industry in Taiwan and India

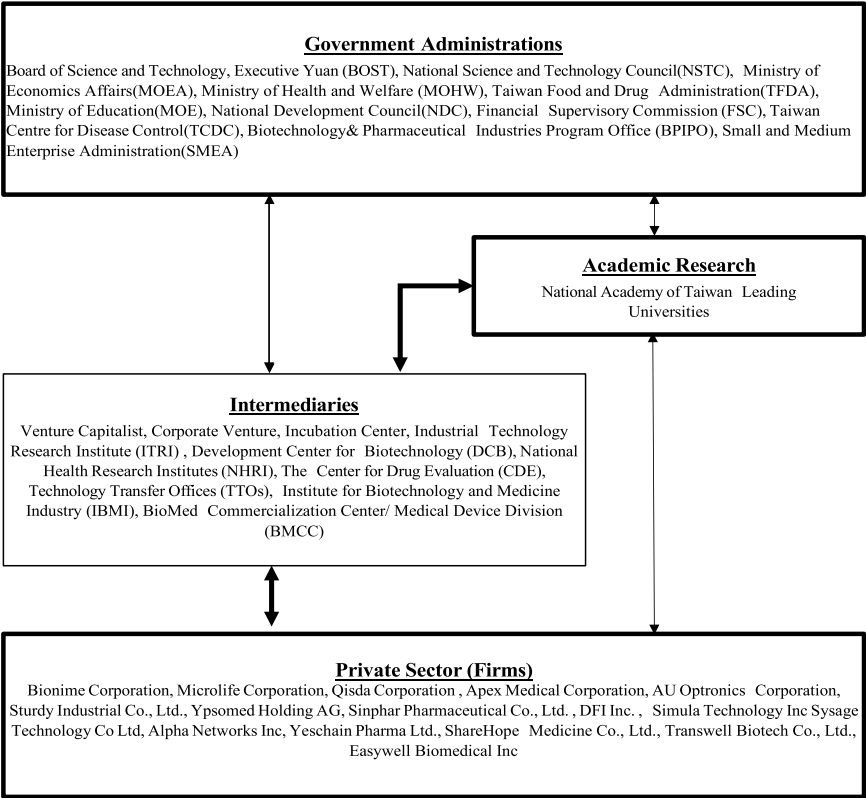
Based on the literature review, industry background, and the result of interviews and social network analysis, this research identifies the important actors in Taiwan and India shown in Figure2 and 3.

Both Taiwan and India have government administrative departments and institutions dedicated to the development and regulation of the medical device industry, including: (1) agencies responsible for overseeing the regulation and promotion of the medical device industry, such as Taiwan's TFDA and India's CDSCO-MD; (2) government departments focusing on promoting the biotechnology industry, such as Taiwan's BPIPO and India's DBT; and (3) government agencies overseeing intellectual property protection and promotion, such as Taiwan's SMEA and India's DPIIT.

On the other hand, Taiwan's Board of Science and Technology and National Science and Technology Council play a bigger role in coordinating and implementing policies related to the industry, while India's Department of Biotechnology and National Biotechnology Development Board are more focused on biotechnology. India has a separate department, the Department for Promotion of Industry and Internal Trade, that supports the growth and development of various industries, including medical devices, while Taiwan's Ministry of Economic Affairs takes on this role. India has a dedicated department for the regulation of medical devices, the Central Drugs Standard Control Organization- Medical Devices, while Taiwan's Taiwan Food and Drug Administration regulates both food and drug products, including medical devices.

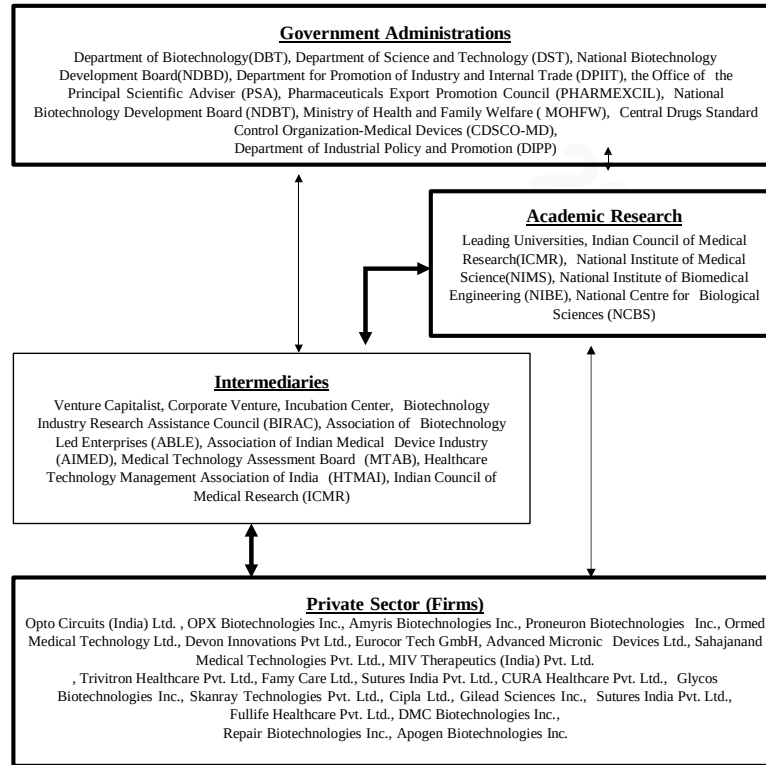
In terms of intermediaries, Taiwan and India have a range of organizations and institutions that support industry development by providing funding, resources, and expertise to entrepreneurs and startups. Regarding the role of academic research institutions. In Taiwan, universities and research institutions

play a key role in conducting R&D and providing talent for industry, while in India, the focus is more on building research infrastructure and supporting startups through incubation and gas pedal programs.



Source: The Authors, based on Mani (2006) and Chen et al. (2016)

Table 2 The Key Actors in Taiwan



Source: The Authors, based on Mani (2006) and Chen et al. (2016)

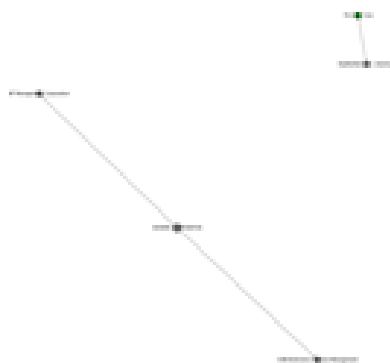
Table 3 The Key Actors in Taiwan

4.3 Networks of Medical Device Industry in Taiwan and India

4.3.1 Changes of the Taiwan's medical device industry in the social network Analysis

In this study, we collect 20 years (2001-2021) of data. This is the social network analysis result of the Taiwan medical device industry. The green nodes are the actor in Taiwan, and the gray nodes are foreign companies. Taiwan companies primarily manufacture plastic-based medical devices. Until 2007, there is a policy initiative encouraging the medical device manufacturers to upgrade to high- end medical devices, then also in the meantime around 2009-2010 intelligent technology quickly develop, and since then we start to apply the intelligent technology to the medical device manufacture, so thereafter our medical device sector gradually develops as shown in the map.

2001-2007



N. of Nodes: 5

N. of Edges: 30

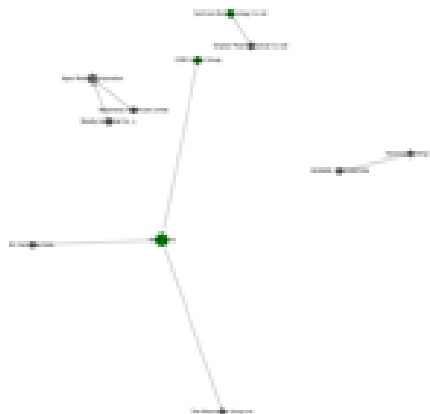
Density: 0.0714

Average node connectivity: 0.0714

Top 10 degree actor:

- BIONIME CORPORATION
- CDIB BioScience Venture Management
- IBT Management Corporation
- HealthTech Inc. (Inactive)
- MicroLife Corp

2008-2014



N. of Nodes: 11

N. of Edges: 78

Density: 0.0199

Average node connectivity: 0.0199

Top 10 degree actor:

- Qinda Corp
- Apex Medical Corporation
- The Blackstone Group Inc
- AU Optronics Corp.
- CDIB Capital Group
- Westmaria Healthcare Limited
- Smedy Industrial Co., L
- BIONIME CORPORATION
- Ypsomed Holding AG
- Singhar Pharmaceutical Co Ltd

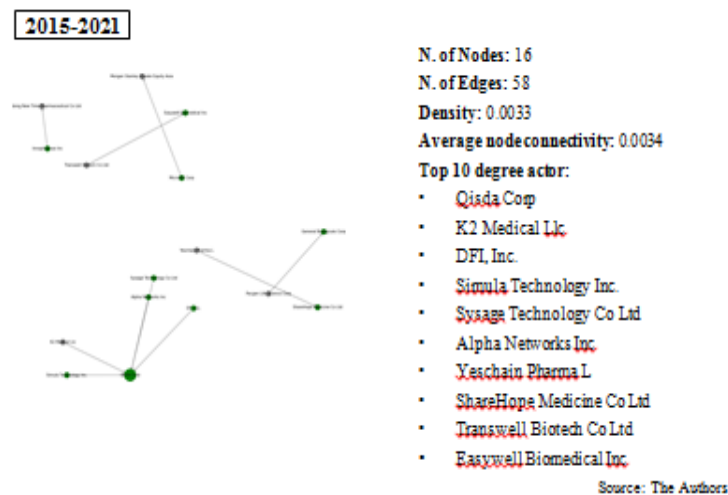


Figure 3 The social network analysis result of Taiwan's medical device industry

In conclusion, looking at the changes in the network relationship and the connection between actors in Taiwan's medical device industry over the past 20 years, we can see that the early development of Taiwan's medical device industry was led by investment companies, while biotech companies played a more peripheral role. However, from 2008 to 2014, Taiwan's established strong ICT industry advantage has made the application of biomedical (Bio) and ICT integration a new development niche, and more and more technology companies are entering the medical device industry and establishing cross-disciplinary cooperation networks. In recent years, the ICT industry has also begun to transform, and Taiwan's medical device industry is focusing on the development of smart biomedicine. Based on the initial investment and the promotion and output of biomedical innovation, biotech companies have become the core force leading the development of Taiwan's medical device industry.

4.3.2 Changes of the India's medical device industry in the social network Analysis

In this study, we collect 20 years (2001-2021) of data. The growth and development of the medical device industry in India can also be seen through the changes in its social network. Indian companies mainly manufacture the low-end medical device. Almost all of them were foreign companies from 2001 to 2007. In recent years, more Indian companies participate.

2001-2007



N. of Nodes: 20

N. of Edges: 24

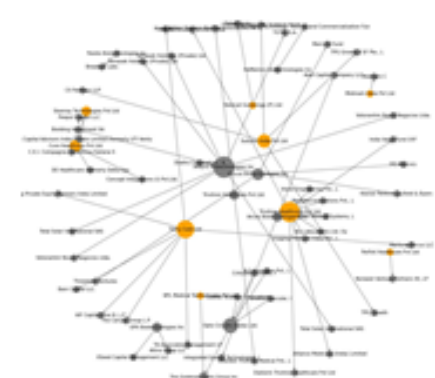
Density: 0.0342

Average node connectivity: 0.0342

Top 10 degree actor:

- ~~Oppo~~ Circuits (India) Ltd.
- ~~OPX~~ Biotechnologies Inc.
- ~~Amvix~~ Biotechnologies Inc.
- ~~Protonex~~ Biotechnologies Inc.
- ~~Omni~~ Medical Technology Ltd.
- Devon Innovations Pvt Ltd
- ~~Enproco~~ Tech GmbH
- Advanced Micronic Devices Limited
- ~~Saba~~ Medical Technologies Pvt Ltd
- MIV Therapeutics, I

2008-2014



N. of Nodes: 71

N. of Edges: 233

Density: 0.0110

Average node connectivity: 0.0183

Top 10 degree actor:

- ~~Amvix~~ Biotechnologies Inc.
- ~~Trinicon~~ Healthcare Pvt Ltd
- ~~Farmy~~ Care Ltd
- ~~Oppo~~ Circuits (India) Ltd.
- Sutures India Pvt Ltd
- ~~Cura~~ Healthcare Pvt Ltd
- ~~Glyco~~ Biotechnologies Inc.
- The Goldman Sachs Group Inc.
- ~~Skaroy~~ Technologies Pvt Ltd
- ~~Trinicon~~ Healthcare Pvt Ltd

2015-2021



N. of Nodes: 16

N. of Edges: 58

Density: 0.0033

Average node connectivity: 0.0034

Top 10 degree actor:

- Cipla Ltd
- Sahajanand Medical Technologies Pvt Ltd
- Gilead Sciences Inc.
- Sunovion India Pvt Ltd
- India Life Sciences Fund II (Evolution India Life Sciences Fund II)
- Trivitron Healthcare Pvt Ltd
- Polaris Healthcare Pvt Ltd
- DMC Biotechnologies Inc.
- Repara Biotechnologies Inc.
- Apogen Biotechnologies Inc.

The Indian medical device industry has grown rapidly due to a large domestic demand market and low manufacturing costs, with many actors participating in each period. During the period 2001-2007, biotechnology and medical technology companies were the major players. Then from 2008-2014, the participation of pharmaceutical and medical device companies increased, with multinational companies as the main actors. However, since the government introduced the "Made in India" policy in 2014 to encourage the development of local companies in India, local companies in India developed and grew rapidly during the period 2015-2021, turning into an important actor. Multinational companies are still involved, but their participation is gradually decreasing. Some companies such as Sahajanand Medical Technologies Pvt Ltd and Trivitron Healthcare Pvt Ltd have maintained an active role in the Indian medical device industry during these various periods. However, from the perspective of R&D and innovation, the Indian medical device innovation system has not been as complete and mature as Taiwan's due to the lack of a complete institutional environment, the lack of focused incentives, and the lack of capacity for human resource development in the early years.

4.4 Comparative analysis of Medical Device Innovation System in Taiwan and India

From the promotion of incentive policies, it can be seen that both Taiwan and India have been actively promoting the development of the biotech industry in recent years. There are increasingly diverse actors joining the innovation systems for medical equipment in Taiwan and India, and the establishment of networks and cooperation in R&D and production are also continuously expanding and becoming increasingly close. Both nations have built their

own networks with international collaborators which mainly based in the US and western Europe independently, but haven't built overlapping international networks between India and Taiwan. On the other hand, from the development process and current situation of the medical equipment industries in Taiwan and India, there are differences in the innovative systems established by the two countries, and the results of the interviews can support the differences proposed in this study.

4.4.1 Government support and Industry Maturity

Both Taiwan and India have government initiatives to support their medical device industries, such as the National Biotechnology Development Strategy in India and the Biomedical Industry Innovation Program in Taiwan. However, the level of government support and the specific policies and programs differ between the two countries. On the regulatory environment and policy incentives in Taiwan, the National Health Insurance system has enabled Taiwan to access new medical technologies and clinical trials. However, at the same time, the system has also led to many Taiwanese companies developing products that cater specifically to the needs of the system, which may not be internationally recognized, making it difficult to enter the international market. The promotion of the Biotech and Pharmaceutical Subsidies Act and tax reduction policies for investors have also brought more funds to the medical equipment industry. Conducting clinical trials in Taiwan is known for being fast and high-quality, which provides an important development space for international pharmaceutical companies that are looking to enter the Greater China market, such as Japan, South Korea, and Southeast Asia.

"The regulations need to be appropriately relaxed, so that medical device manufacturers can have more incentives to do high-end research and development work."

"There are many advantageous aspects in Taiwan, but it is necessary to take a more macro perspective. In the past, these things were only targeted for use in the National Health Insurance system. If you want to make them into internationally recognized and widely used standards, it may still require effort and direction. "

"Currently, the government is actively promoting Taiwan as a good location for clinical trials, which is also one of Taiwan's advantages and an important development space. This can bring opportunities to Taiwan. "

The Indian market is massive, with potential and attractiveness, but this also requires a longer-term investment of significant resources and effort to establish and mature the medical equipment innovation system in India. The Indian government has launched the "Make in India" program to attract domestic and foreign companies to establish manufacturing plants in India. In addition, with

an aging population and increasing medical demand, the Indian medical equipment market is gradually expanding. However, the Indian medical equipment market still faces some challenges, such as low equipment quality, low technological levels, inadequate intellectual property protection, and intense market competition. Therefore, to succeed in the Indian medical equipment market, one needs sufficient market insights, resources, and experience, as well as patience and long-term strategic planning. During the establishment and development of the network, due to the relatively small domestic market and less mergers and acquisitions in Taiwan, local companies are unable to expand their product lines gradually like international giants, and therefore need to rely on strategic alliances or resource and platform integration. Some

Taiwanese companies have also collaborated with international pharmaceutical companies to gain regulatory guidance resources and have a timelier understanding of international demands.

"The medical level in India is actually quite polarized. Private hospitals in India can be very high-end, but if they are profit-driven, they only serve those who can afford to pay out-of-pocket. If there is no rooted research in this area, I think it will be difficult to drive the local medical device industry."

"In the medical device industry, collaboration is typically done through alliances and teamwork. We often seek key partners to work on joint research and development or collaborate within the company. Most companies do not work independently, but rather join various associations or collaborate with partners through strategic alliances to jointly develop or research products. Although there is competition, we tend to compete through strategic alliances rather than independently resisting. "

"We hope to understand the context of international large corporations through collaboration with them and to know what they want. By knowing where the international demand lies, we can provide a direction for our future promotion. "

4.4.2 Innovation capabilities and Industrial transformation

Compared with the pharmaceutical sector, India has been relying on cooperation with the US in the medical device sector. One of the reasons is that technology followers usually take technology from those leading countries such as the US or western Europe. Both Taiwan and India have invested in talent development for their medical device industries, but the focus and strategies differ. Taiwan has a strong focus on cultivating interdisciplinary talent and collaboration between academia and industry, while India has emphasized partnerships with foreign universities and attracting talent from abroad.

"In the medical device industry, cooperation is usually done through alliances and group efforts. We typically seek out key partners to engage in joint research and development, or engage in company-wide collaborations. Most companies in this industry use this approach, rather than going it alone. We join many unions, or partner with our collaborating factories through strategic alliances to jointly develop or research products. Even though there is competition, we still use the strategic alliance approach to compete, rather than resist independently. Our products, markets, and customers are all developed through this cooperative approach."

"Basically, the innovative R&D ideas in medical device companies in India are driven by a combination of market needs, technological advancements, and a desire to stay ahead of the competition. And we look forward to be competitive in the space and find some real time digital solutions of the problems. "

"The growth factor driving the demand of medical devices in India including growing population; ageing population; growing medical tourism; demand to go as par with international standards; demand for healthcare infrastructures after. "

Additionally, Industry transformation usually means facing new market and technological trends, and innovation can bring competitive advantages to businesses, thereby driving industry transformation. At the same time, industry transformation also provides broader application scenarios and market demand for innovation, promoting innovation to continuously move forward. In Taiwan, most of the respondents indicated that they have considered relevant transformation strategies or cross-domain integration, as local companies are at a disadvantage in terms of resources compared to international giants. The main approach is to diversify their products by expanding into other areas, or to transform their products into intelligent ones, achieving added value and enhancing their own competitiveness. Among them, key technologies can be obtained through technology transfer, industry-academia cooperation, or clinical methods. India has a vast domestic market, which provides a broad space for the development of the medical device industry. The Indian medical device industry also faces some challenges, such as technological backwardness, low productivity, insufficient patent protection, and so on. These issues also require the support of industry transformation and innovation to enhance the industry's competitiveness and sustainable development capability. At the same time, India can also use the application of emerging technologies as an opportunity for industry transformation.

"There are two approaches, one is technology transfer and the other is differentiated analysis for product development. For example, our products such as upgraded hospital beds or positioning series were developed by our

R&D team. Some parts were obtained through technology transfer, industry-academia cooperation, or clinical methods."

"Taiwan possesses a complete medical equipment industry chain and has a strong foundation in research and development, design, and mechanical manufacturing. In addition, with the thriving development of the ICT industry and the clinical demand provided by major medical systems, there is potential to create more new business opportunities through the integration of industry, government, academia, research, and medical resources."

"If it's related to digital and information, I think that's where India has an advantage in the international arena. Many foreign software companies inside the engineers, are Indian."

"Most of the people most of the business men in India, focus on bringing in Medical devices that have better or good profits. Rather than good applications. Maybe we can focus on bringing technology Into India. "

5. Conclusion

5.1 Development of Taiwanese and Indian medical device innovation system in the past two decades

This study provides insights into the construction of sectoral innovation system in the medical device industry in Taiwan and India. The medical device industry is a cross-disciplinary technology industry with unique characteristics of small quantities and diversity. Mainstream products are constantly changing with changes in disease forms, product R&D, and technological advancements.

Taiwan has a well-established and coordinated system of policies and agencies dedicated to promoting the development of the medical device industry, including the Ministry of Economic Affairs, the Ministry of Science and Technology, the Food and Drug Administration, and the Industrial Development Bureau. Taiwan has long experience in the ICT field and the technology of wheelchair assistive device manufacturing has led to the rapid development of smart medical devices by introducing smart technology. In Taiwan, however, there is no significant growth trend, though the medical device firms adopted intelligent technologies in their product developments in recent years. we have found the medical device industries in Taiwan have gradually developed over the past 20 years, and has established its own international partners, mostly from the U.S. and Japan.

In contrast, India has a fragmented system with multiple agencies responsible for different aspects of the industry, which can lead to coordination challenges. To overcome these challenges, the Indian government is strengthening regulation and supervision of the industry, and also promoting related training

and education programs to improve the industry's technical and quality standards. India is on the growth path with major percentage of its population with higher disposable income. Affordable healthcare services across the country's socio-economic strata, including the rural populace through improved medical infrastructure provided by the government, need immediate attention. A huge growth opportunity is forecasted due to demand-supply dynamics for the manufacturing of medical devices in India. An estimated increase in per capita consumption is also foreseen for medical devices. India can contribute as 'Pharmacy of the World' and has huge potential to access new markets with innovative indigenous medical devices. India can rule the technology competition landscape with building innovation system and focused manufacturing of low and mid-tech products.

Faced with the rapid changes in the industrial environment and technological applications, the medical device manufacturers can respond flexibly through diversified business models. Especially under the trend of global cross-domain integration, they can expand the scope of cooperation, establish diversified cross-domain cooperative relationships, and integrate the upstream, midstream, and downstream supply chains of the original industries to facilitate more cross-industry cooperation. By grasping key R&D technologies and planning for the development of potential products, they can lay out diverse markets to meet the demand-oriented development opportunities in the medical field. Strengthening product marketing strategies and establishing distribution channels can create product value and create new growth momentum.

5.2 The Interaction between institutions and medical device innovation system

During 2001-2007, Taiwan focused on the development of monitoring products, and the entry of investment companies focusing on the biotechnology field during this period was the beginning of Taiwan's medical device industry led by investment companies. In India, multinational companies played a more important role in the network relationship at the early stage of medical device industry development, however, the tariff for medical device products was relatively low at that time, and many multinational companies did not set up production bases in India although they had been operating in the Indian market for many years.

During 2008-2014, policy measures to encourage the development of the biotechnology industry continued to be proposed, e.g., the integration of biomedicine and ICT as the main driving direction, and to encourage smart technology companies to enter the medical device industry, which led to an increasing number of smart technology companies joining the field of medical device industry as one of the main actors at that time. These companies entered the biotechnology field with their technological background and manufacturing capabilities to produce and sell medical devices and related products. During

this period, investment firms continued to be important actors in the network, but biotech and medical device companies also grew in importance. India, on the other hand, is facing a transformation driven by the government, with the cultivation of talents, the establishment of industrial clusters, and the establishment of an institutional environment being the focus of this phase. In addition to setting up factories there, they also adopt the strategy of shifting their export production capacity to domestic sales as the local market grows, and with the establishment of R&D centers and expansion of factories, they have been cultivating the Indian market for a long time.

After 2015, it can be seen that biotech companies have become the core force leading the development of Taiwan's medical device industry due to the establishment of a complete regulatory environment, the promotion of incentive policies, and the early investment in R&D. These key players are producing a wider range of products and services, covering different aspects of medical device production. India's medical innovation system has seen rapid development and growth since the government introduced the "Made in India" policy, and local companies have become important players. Multinational companies are still involved, but not as important as before.

Taiwan's medical device industry's success is attributed to several factors including but not limited to international market growth for devices, technological innovation, financial investment spike, skilled manpower, and strong governmental initiatives to boost the industry. The enforcement of GMP regulations facilitated the transformation of Taiwan's local medical device industry. The GMP standards protected the local industry while at the same time boosted the domestic markets. Policymakers' world over need to understand and evaluate the bearing of regulatory requirements on small and medium enterprise manufacturers and should focus on implementing a harmonized regulatory system that will alleviate the impact, thereby ensuring the success of the policy's implementation. Taiwan's medical device manufacturers are mostly small and medium-sized enterprises with limited capital access. In the face of severe challenges and development bottlenecks in the international market, relaxing regulations, accelerating commercialization processes, and providing a friendly research environment are the most urgent needs of the medical device industry in Taiwan.

In comparison, India's institutional features, including multiple regulatory systems, lack of clear accreditation standards, a plethora of legal requirements, and the need for quality assurance procedures have influenced the development of India's medical device industry, resulting in the innovation system not yet ready for the convergence of intelligent technology and biotechnology. India can rule the technology competition landscape by building an innovation system. India needs such an innovative system in the medical devices industry to promote both the local industries and foster international

collaborations for sustained competitive advantage. One of the niches that India has is that they are good at reverse engineering, and also that the ICT sector is very well developed in India, so they might consider setting up some kind of human resource training program, trying to send their young scholar abroad to acquire the new technology.

5.3 Recommendations and Future Work

At present, we have built the sectoral innovation system in Taiwan and India. In the future, we plan to develop medical device ecosystem, including business ecosystem, technology ecosystem, and science ecosystem to further explore the divergent development paths of the medical device industries, and to identify opportunities for cross-learning and collaboration between the two countries.

In conclusion, this paper compared the medical device innovation systems in Taiwan and India, highlighting the progress made by both countries in fostering innovation in this sector. Taiwan has a well-established ecosystem that emphasizes R&D investment, collaboration between industry and academia, and a robust regulatory framework. In contrast, India's ecosystem is more fragmented, with less developed regulations and greater reliance on foreign investment and technology transfer.

To further develop their medical device industries, both Taiwan and India must continue to invest in R&D, strengthen industry-academia collaboration, and establish effective regulatory frameworks that balance innovation and patient safety. They should also improve funding opportunities for startups and enhance the overall business environment for the industry. By doing so, both countries can become leaders in the global medical device market, contributing to improving healthcare outcomes worldwide.

Moving forward, it will be important to build technology and science ecosystems to enhance mutual learning and create more diverse opportunities for cross-industry collaboration. By capitalizing on key R&D technologies and planning for the development of potential products, medical device manufacturers can expand their markets and meet the growing demand for innovative medical technologies.

Reference

- Agrawal, A. K. (2001). University-to-industry knowledge transfer: Literature review and unanswered questions. *International Journal of management reviews*, 3(4), 285-302.
- Bartholomew, S. (1997). National systems of biotechnology innovation: complex interdependence in the global system. *Journal of international business studies*, 28, 241-266.
- Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research policy*, 37(3), 407-429.
- Braun, V., & Clarke, V. (2012). *Thematic analysis*. American Psychological Association.
- Bunnell, T. G., & Coe, N. M. (2001). Spaces and scales of innovation. *Progress in Human geography*, 25(4), 569-589.
- Chang, T.-Y. (2012). Strengths of Taiwan's Medical Device Industry. *International Journal of Automation and Smart Technology*, 2(1), 3-6.
- Chaturvedi, S. (2005). Evolving a national system of biotechnology innovation: some evidence from Singapore. *Science, Technology and Society*, 10(1), 105-127.
- Chen, S., Forbes, I., & Martin, P. (2016). Knowledge transfer and the biopharmaceutical innovation system in Taiwan. In *Innovation Systems and Capabilities in Developing Regions* (pp. 121- 142). Routledge.
- Chen, Y.-J., Chiou, C.-M., Huang, Y.-W., Tu, P.-W., Lee, Y.-C., & Chien, C.-H. (2018). A comparative study of medical device regulations: US, Europe, Canada, and Taiwan. *Therapeutic innovation & regulatory science*, 52(1), 62-69.
- Cheong, S. T., Li, J., Ung, C. O. L., Tang, D., & Hu, H. (2020). Building an innovation system of medical devices in China: Drivers, barriers, and strategies for sustainability. *SAGE Open Medicine*, 8, 2050312120938218.
- Cleland, P. D., & Manley, S. E. (2007). 4. Science and technology policy and diffusion of knowledge in New. *Science, Technology Policy and the Diffusion of Knowledge: Understanding the Dynamics of Innovation Systems in the Asia Pacific*, 98.
- Cooke, P. (2001). Regional innovation systems, clusters, and the knowledge economy. *Industrial and corporate change*, 10(4), 945-974.
- Cooke, P., Uranga, M. G., & Etxebarria, G. (1997). Regional innovation systems: Institutional and organisational dimensions. *Research policy*, 26(4-5), 475-491.
- Datta, P., Mukhopadhyay, I., & Selvaraj, S. (2013). *Medical devices manufacturing industry in India: market structure, import intensity and regulatory mechanisms*. ISID-PHFI Collaborative Research Centre, Institute for Studies in Industrial
- Edquist, C., & Chaminade, C. (2006). Industrial policy from a systems-of-innovation perspective. *EIB papers*, 11(1), 108-132.
- Freeman, C. (1991). Networks of innovators: a synthesis of research issues. *Research policy*, 20(5), 499-514.
- Freeman, C. (1995). The 'National System of Innovation' in historical perspective.

- Cambridge Journal of economics*, 19(1), 5-24.
- Freeman, L. (2004). The development of social network analysis. *A Study in the Sociology of Science*, 1(687), 159-167.
- Jamali, M., & Abolhassani, H. (2006). Different aspects of social network analysis. 2006 IEEE/WIC/ ACM International Conference on Web Intelligence (WI 2006 Main Conference Proceedings)(WI'06),
- Jarosławski, S., & Saberwal, G. (2013). Case studies of innovative medical device companies from India: barriers and enablers to development. *BMC health services research*, 13(1), 1-8.
- Jaroslawski, S., Saberwal, G., & Pafitis, D. M. (2013). Novel affordable medical devices: case studies of innovative companies from India.
- Jensen, M. B., Johnson, B., Lorenz, E., Lundvall, B.-Å., & Lundvall, B. A. (2007). Forms of knowledge and modes of innovation. *The learning economy and the economics of hope*, 155.
- Kale, D., & Wield, D. (2019). In search of the missing hand of 'collaborative action': evidence from the Indian medical device industry. *Innovation and Development*, 9(1), 1-23.
- Lundvall, B.-Å. (1992). User-producer relationships, national systems of innovation and internationalization. *National systems of innovation*.
- Mahal, A., & Karan, A. K. (2009). Diffusion of medical technology: medical devices in India. *Expert Review of Medical Devices*, 6(2), 197-205.
- Mahal, A., Varshney, A., & Taman, S. (2006). Diffusion of diagnostic medical devices and policy implications for India. *International journal of technology assessment in health care*, 22(2), 184-190.
- Malerba, F. (2002). Sectoral systems of innovation and production. *Research policy*, 31(2), 247- 264.
- Malerba, F. (2005). Sectoral systems of innovation: a framework for linking innovation to the knowledge base, structure and dynamics of sectors. *Economics of innovation and New Technology*, 14(1-2), 63-82.
- Malerba, F., & Montobbio, F. (2003). Exploring factors affecting international technological specialization: the role of knowledge flows and the structure of innovative activity. *Journal of evolutionary economics*, 13, 411-434.
- Mani, S. (2006). The sectoral system of innovation of Indian pharmaceutical industry.
- Nelson, R. R. (1993). *National innovation systems: a comparative analysis*. Oxford University Press on Demand.
- Patton, M. Q. (1990). *Qualitative evaluation and research methods*. SAGE Publications, inc.
- Radhadevi, N., Balamuralidhara, V., Kumar, T. M. P., & Ravi, V. (2012). Regulatory guidelines for medical devices in India: An overview. *Asian Journal of Pharmaceutics (AJP)*, 6(1).
- Van de Ven, B. (2008). An ethical framework for the marketing of corporate social responsibility. *Journal of business ethics*, 82, 339-352.

- Weigel, S. (2011). Medical technology's source of innovation. *European Planning Studies*, 19(1), 43-61.
- Wield, D., Hanlin, R., Mittra, J., & Smith, J. (2013). Twenty-first century bioeconomy: Global challenges of biological knowledge for health and agriculture. *Science and Public Policy*, 40(1), 17-24.
- Zucker, L., Darby, M., & Armstrong, J. (2000). University science, venture capital, and the performance of US biotechnology firms. *Mimeogr., Univ. Calif. Los Angeles*.

Endogenous Knowledge and Secondary Innovation in the age of COVID-19: A Global South Civilisational Dialogue

Ogundiran Soumonni

Wits University, South Africa

Mammo Muchie

Tshwane University of Technology, South Africa

Abstract

We begin our reflection in this paper with the cursory observation that most of the major variants of the SARS CoV-2 virus were deciphered in the Global South, namely, alpha (China), beta and omicron (South Africa). This underappreciated fact demonstrates that independent capabilities in frontier sciences in the South contributed fundamentally to global efforts to minimise the human cost of the pandemic. However, while the more efficient vaccines primarily emerged from R&D-based capabilities in the Global North, some novel vaccines, secondary innovation in the form of manufacturing, and the innovative deployment of preventive measures were also salient in the Global South. Thus, rather than start with the 'deficit model of development' that is implicit in several policy discourses on the Global South, we argue that innovation concepts should instead be anchored in the rich civilisational heritage of such societies themselves. Theoretical notions as secondary innovation, which emerged from Chinese efforts at economic catch-up, endogenous development, which seeks to ground Africa's advancement in its own historical antecedents, and grassroots innovation from the Indian subcontinent, guide our South-South dialogical exchange in this paper. Consequently, we propose a contextually rooted conceptual framework on endogenous innovation that could better inform socially transformative efforts, and highlight some implications for medicinal innovation and astronomy beyond COVID-19.

1. Anchoring Innovation Discourses in the Global South

The crucial role that innovation has played in mitigating the adverse impacts of the COVID-19 pandemic around the world offers an opportunity to reflect on the diverse societal responses on the basis of their own tangible and immaterial resources. Our core argument in this paper is that many such domestic responses underscore the imperative of re-centring innovation discourses in the cultural imaginaries and intellectual heritages of Global South societies themselves. Such a conceptual orientation, we contend, is necessary for them to achieve more meaningful human developmental outcomes within a relatively short time horizon. A corollary to this proposition is that insofar as the more influential innovation theories tend to emerge in the Global North, the locally and yet, globally relevant intellectual inquiry directed by the Global South is more likely to be decisive for its peoples' quest for a more just socio-economic and environmental international order. This heightens the need for a South-South dialogue that is based on a critical re-appropriation of insights from the hemisphere's diverse civilisations, rather than an acquiescent implementation of dominant paradigms. From an African perspective, such an imperative for a post-COVID-19 world was poignantly captured in a recent keynote address by the distinguished sociologist and gender scholar, Oyeronke Oyewumi, in the following quote:

'Africa is a treasure trove not only of Benin bronzes, coltan from the Democratic Republic of the Congo, and diamonds from Botswana. The real unmined gems are African concepts, ideas, values, ways of being and systems of knowledge and episteme.' (Oyewumi, p. 4).

Theoretical rejuvenation as a vital dimension of human development is fairly widespread in scholarly debates around the foundations for nation-building in many social science disciplines, with frequent historical references to the Meiji Restoration in 19th Century Japan, for instance, Ujamaa (African socialism) in Tanzania in the 1960s, and more recently to the 'civilisational state' in 21st Century China. Conversely, while an increasingly pertinent discourse on innovation systems, particularly with respect to the Global South, sympathetically acknowledges the importance of the culturally-embedded knowledge heritage of various societies in achieving more relevant developmental outcomes, it generally does so in a propositional manner. This 'broad perspective' on innovation systems, as opposed to the 'narrow perspective' that centralises the generation and diffusion of scientific research and development (R&D) as its core functions, is one that nevertheless requires more specific content and systematisation. In an effort to deepen the scope of such considerations, we therefore anchor our analysis of innovation activities in a diachronic or temporal consideration of illuminating historical, philosophical, and economic bases for their sites of expression, and in a spatial interchange across geographic and cultural expanses.

The constant dialectic between the past and the present, and between the local and the global, is the living essence of the theory and praxis of endogenous development, influentially articulated by the late, pioneer African historian from Burkina Faso, Joseph Ki-Zerbo (Ki-Zerbo, 1992). We also lean on the articulation by the preeminent Indian historian, Romila Thapar, of a civilisation as inclusive of both an internal dynamic or ‘indigenous genesis’, and transmission from other cultures, which features concessions as much as contestations (Thapar, 2001). Our grounding of this dialogue across space and time, following Ki-Zerbo, is in ‘endogenous knowledge’, cursorily understood to signify that ‘knowledge of self’ is the properly-suited basis for a reciprocal valorisation of diverse knowledge systems. These perspectives therefore reflect the civilisational outlook that foregrounds our paper.

With respect to contemporary studies on innovation in the Global South, there are a number of notable exceptions, particularly in relation to East Asia, whereby innovation scholars root their work, to varying degrees, in the deeper intellectual heritage of such societies. We highlight a few of these at some length due to the widely acknowledged economic success of most of this region while leveraging the best of its cultural antecedents. For instance, in discussing the notion of ‘harmonious development’ in China, which seeks to simultaneously address social and environmental challenges, Gu and Lundvall (2006) ground it in examples of China’s ancient contribution to the world’s scientific and technological knowledge through its introduction of the compass, paper and gunpowder. They also premise it upon the Confucian heritage, which conferred enormous intellectual prestige on public officials and humanities scholars, although they argue that science and technology were largely based on practical experience until the establishment of formal R&D institutions in the 1950s (Gu & Lundvall, 2006). Gu et al. (2016) have subsequently highlighted the contemporary state policy of *zizhu chuangxin* or endogenous innovation, understood as socio-economic development that is driven by domestic science, technology and innovation (STI) actors, which has marked a clear shift in emphasis from imitative innovation to self-directed, R&D-driven innovation. Shulin Gu and her research collaborators reveal that this is concurrently implemented alongside *baorongxin chuangxin* or inclusive innovation. Inclusive innovation, in their view, extends this focus on cutting-edge, STI-led innovation by further relating it to existing problems in industry, using it to boost the capabilities of existing firms, and encouraging lifelong learning. Such an orientation can be observed in rural e-commerce initiatives like the Taobao villages that promote ‘harmonious development’ (Gu et al., 2016).

Wu and Li (2015) likewise use the term ‘endogenous innovation’ in their theorisation of secondary innovation, which they define as a co-evolutionary

process of technological and business model innovation that is deployed by resource poor firms in latecomer economies to acquire, assimilate, improve, and ultimately capture a larger market share. However, in the preface to his co-edited book on Huawei's transformation, Xiaobo Wu suggests that the integration of China's traditional concepts into management theories from the West helped to explain the success of its firms (Wu, 2020). Nevertheless, Wu suggests that the resultant practices were so different that such enterprises could no longer simply be thought of as the 'Confucian merchants' of ancient times. It is also made clear in the book that Huawei's founder, Ren Zhengfei, tries to apply Chinese philosophical principles such as the four spheres of living (innocent, utilitarian, moral and transcendent), and the Confucian ethos of worker commitment while caring for the wider society (Lewin et al., 2020). Similarly, the noted organisational innovation theorists, Ikujiro Nonaka and Hirotaka Takeuchi, demonstrate that in light of the volatile, uncertain, complex and ambiguous (VUCA) world inaugurated by the COVID-19 pandemic, practical wisdom, understood as prudent, timely and human-centred judgements drawn from Japanese folk wisdom have been critical in preserving the resilience of Japan's firm that is, over and above the computational power of digitally-led automation (Nonaka & Takeuchi, 2021).

From the point of view of national preconditions for economic catch-up, Lee (2016) locates the origins of the East Asian activist state model in the Chinese Qin Dynasty (221-206 BCE). More specifically, Keun Lee explains its high level of capacity as being due to the Confucian legacy of state autonomy (from both internal partisanship and external interests) as well as the extremely selective and well-trained bureaucracy. What is of utmost significance to us in these examples is that the sources of endogenous innovation need not be limited to the 'rational', profit maximising activities of domestic firms as in neoclassical economic models. And neither should they be restricted to the confines of contemporary Westphalian states in the Global South. As the political theorist Adom Getachew has ably argued, the latter often reflect the enduring logics of economic and political subordination that characterised their creation (Getachew, 2020).

Our subsequent analyses in this study, therefore transcend administrative boundaries, as called for in the theory of endogenous development (Ki-Zerbo, 1992). They are also informed by the call made nearly two decades ago by Muchie (2004) for researchers to utilise an 'emancipatory methodology' to entrench a 'total learning and innovation culture' that can enable human, attitudinal, institutional and structural transformation in Africa and elsewhere in the Southern hemisphere. The introductory considerations above therefore inform our key concern in this paper. In the face of the differential socio-economic impact of the COVID-19 outbreak globally, what unique features of innovative responses in the Global

South could inform a conceptual reinvigoration of endogenous innovation in the post-pandemic hemisphere?

2. Endogenous Innovation in Transversal Perspective

2.1 Some Early Historical Antecedents

As suggested in the introductory section above, a key premise of our paper is rooting endogenous innovation in a civilisational perspective because, as Ki-Zerbo (1993) reminds us, the contemporary nation-state is a legacy of 19th Century Europe that must itself be transcended in favour of the positive, particular values of various communities that link them to universal ones through a dialectical process. As such, a transversal or cross-cutting comparative approach is needed to underscore themes that may resonate, as well as elicit contestations, both within and across cultures. In a similar vein, Romila Thapar (2001) challenges earlier notions of civilisations as characterised by a narrow rationalism, as being geographically static, culturally monolithic, prone to violence or a “clash” with others, in favour of a more inclusive and dynamic interpretation. Instead, she views civilisations as encompassing a diversity of cultural forms within a wide territory (Thapar, 2001).

From a historical vantage point, Thapar’s insight about the openness of civilisations is accentuated in Ki-Zerbo’s critique of the recency bias in ‘modernisation’ theories. These typically neglect the diverse roots of contemporary science and technology, such as in Ancient

Nile Valley civilisations from the prehistoric age to the 6th Century BCE; Chinese science from the 11th to the 15th centuries ACE; Arabo-Islamic science, which flourished from the 12th to the 13th centuries ACE (drawing on the heritage of Persia, Pakistan, India, Andalusia, Egypt, Greece, etc.); European science as from the 15th century ACE, and many more (Ki-Zerbo, 1992). It is in these senses, then, that we refer to ‘endogenous knowledge’ as encompassing both the cumulative stock of scientific knowledge, as mutually constituted with technological change, and societally determined imperatives for its acquisition, recombination and deployment as ‘endogenous innovation’.

2.2 Philosophical Groundings

The relevance of a civilisational perspective was evident in the widely reported meetings in Germany in 1930 between the celebrated physicist, Albert Einstein, and the renowned man of letters, Rabindranath Tagore, both of them Nobel Prize laureates, on the nature of reality. In two separate philosophical conversations reproduced in the book *Science and the Indian Tradition: When Einstein*

met Tagore by Gosling (2007, pp. 161-164), both men expressed similar perspectives on the concept of beauty, but contrasting views on that of whether scientific truths exist independently of the human mind or in conjunction with it. On the surface, the two thinkers appeared to be drawing from distinct intellectual traditions (modern physics and Indian philosophy). However, Tagore also had close relationships with other exceptional scientists, notably, the Indian physicist and botanist, Jagdish Chandra Bose, on whom he leaned to shape his appreciation of the interrelationship between the sciences and the arts (Visvanathan, 2013). This awareness of interconnections, which was the basis of Tagore's rejection of scientism or positivism (rather than of science itself), shaped a mutually fruitful interaction with the famed quantum physicist, Werner Heisenberg, in 1929 (Radice, 1998).

Conversely, Tagore's aesthetics of science and technology appear to have been at variance with those of Mahatma Gandhi. While Tagore privileged free civilisational interchanges and a 'dialogue of differences' (including with the West) in order to prevent monotony, Gandhi's greater concern lay with the risk of mimetism and the devastation of local communities through the use of machines (Visvanathan, 2013). Nevertheless, Gandhi's own influence on the West is evident, for example, in *Small is Beautiful*, the popular book by the British-German economist and founder of the Appropriate Technology movement, E.F. Schumacher.

2.3 Economic Bases

In light of the profound flows of knowledge and insights in the first half of the 20th Century described above, we find the detailed analysis of original texts in German by Reinert and Reinert (2006) on the origins of the influential metaphor of 'creative destruction' in the economics of innovation to be compelling. This concept, which describes the process of obsolescence and renewal that ensures the long-term growth of economies, is most widely attributed to the Australian economist, Joseph Schumpeter. However, it can be traced to its earlier use by the German economist, Werner Sombart, who explicitly acknowledged his indebtedness to the philosopher, Friedrich Nietzsche, for it (Reinert & Reinert, 2006). According to Hugo Reinert and Erik Reinert, Nietzsche can in turn be firmly placed in an immediate intellectual environment at the University of Basel in Switzerland, in which metaphysical notions like that of Shiva in Hindu philosophy circulated widely. Indeed, we find in Rabindranath Tagore's work, a poem originally written in 1883 and entitled '*Brahmā, Visnu, Śiva*', which aesthetically captures the attributes of this deity of destruction and creation, as can be seen in the excerpt below (Tagore, 1994, p. 46):

*'Wake, wake, great Śiva,
Our body grows weary
Of its law-fixed path,
Give us new form.
Sing our destruction,
That we gain new life.'*

While we find this origins story to be fascinating in relation to the evolution of endogenous knowledge, we are even more interested in the various possible interpretations of the 'creative destruction' metaphor with respect to innovation over time and in different parts of the world, including in the Indian subcontinent itself. For example, it is well known that Schumpeter first introduced the term in his 1942 work entitled *Capitalism, Socialism and Democracy*. Yet, he had first described the process itself in his *Theory of Economic Development*, which was first published in 1911. The earlier and later perspectives are known to innovation scholars as Schumpeter Mark I and Mark II, respectively. Malerba and Orsenigo (1995) attribute Mark I, which is associated with small, new, forceful and disruptive entrepreneurs to 'creative destruction', while they ascribe Mark II, driven by large firms with internal R&D capabilities, to 'creative accumulation'. Even though we agree with the identification of these different emphases in the two works above by Schumpeter, our independent reading of *Capitalism, Socialism and Democracy* suggests that he used the term 'creative destruction' to refer to both phenomena, but with greater prominence on the latter. We quote him briefly below to emphasise our key point:

'Our argument however extends beyond the cases of new concerns, methods and industries. Old concerns and established industries, whether or not directly attacked, still live in the perennial gale.' (Schumpeter, 2003, p. 90)

The notion of the 'perennial gale', then, appears to be Schumpeter's revised understanding of creative destruction, which subsumes his earlier characterisation of firms becoming obsolete by not being able to overcome crises – but subsequently preferring the notions of 'orderly retreat' and 'orderly advance' for those that survive (Schumpeter, 2003, p. 90). Given this changing interpretation of 'creative destruction', as well as the fairly different European and American contexts of its application, it is legitimate to ask open questions such as the following: How might the metaphor be applied differently to innovation in the Indian cultural context from which it initially emerged? Furthermore, how could it inform innovative responses to demographic explosion, global climate change, fragile healthcare systems, increased unemployed in the face of COVID-19, and attempts by Global South societies to reverse global inequality?

A second query relates to Schumpeter's predominantly internal account of creative destruction as the basis for economic development during the first half of the 20th century when colonial rule was still rife around the world. And despite his acknowledgement of the exploitative nature of colonial subjugation, as the Nigerian economic historian, Joseph Inikori (2002), has pointed out in his authoritative work, *Africans and the Industrial Revolution in England*, the overwhelming focus of Schumpeter's analyses were on the leading industrialised economies of his day, namely, the United States, Britain and Germany. The equally respected Indian historian, Irfan Habib, has similarly challenged the emphasis on domestic productive forces in explaining the First Industrial Revolution. His work demonstrates that the overwhelming contribution to England's industrialisation was underpinned by 'tribute from conquest' and the associated destruction of India's textile industry (Habib, 1975). Likewise, the Indian political economist, Amiya Kumar Bagchi, in his review of Habib's work, favourably cites Inikori's assessment that international trade, namely, the import substitution of Indian textiles with British products, is a more persuasive argument for helping to explain the Industrial Revolution in England than interpretations that prioritise internal socio-political dynamics in explaining technological change in that revolution (Bagchi, 2015). Thus, given the attendant global inequality inaugurated by that historical period, we would emphasise 'creative construction', suitably embedded in a cultural context, as the aspect of the metaphor that better captures the imperative of significantly more equitable educational, social, health and environmental outcomes.

2.4 Transnational Communities

Our brief discussion of diverse historical, philosophical and economic antecedents for endogenous innovation travels through the eyes of various thinkers, whose own identities traversed and transcended continually changing national borders. This lends credence to our proposition that civilisational reference points should be elevated in Global South innovation discourses, in particular. In the national systems of innovation literature, an extremely rich article by one of its pioneers, Chris Freeman (2002, p. 194), recognised the centrality of 'changing forms of political organisation and territorial boundaries', such as principalities, city-states, and empires, before nation-states became preponderant. From an African perspective, however, a deeper understanding of this evolution (and indeed, co-existence) of forms is required for an adequate appreciation of the possibilities of constructing suitable and effective innovation systems.

In a keynote address delivered at the India International Centre in New Delhi in 2008 entitled, *Africa, the African Diaspora and the Prospect of Global Cultural Dialogue*, the esteemed Beninese linguist, literary theorist and diplomat, Olabiyi

Yai, offered the following epistemological understanding of Africa:

‘... when I refer to Africa, I mean the sum total of African cultures, as sedimented for millennia in philosophies, wisdoms, ways of knowing, ways of being and doing things as well as of relating to otherness’ (Yai, 2008).

Yai contrasts the understanding above with what he calls the ‘problematic Africa’ - that which is associated with its imposed upon partition consecrated at the Berlin Conference (1884-1885), with human misfortunes, and an alienated elite running most of its states (Yai, 2008). He also quotes Rabindranath Tagore’s poem, *Africa*, at length, which demonstrates a deep appreciation of the multi-millennial history of the African continent as the backdrop for its subsequent predicament - ironically, through what Tagore called the ‘barbaric lust of civilized men’ (Tagore, 1994, p. 102).

Another integral component of this historically informed appreciation of Africa is its Diaspora, most of whose members were forcibly displaced to the Americas, Arabia, and elsewhere. The vibrancy of their interactions, circular movements and knowledge flows has led scholarly networks and international organisations, particularly UNESCO, to propose the innovative concept of ‘Global Africa’ to capture such transnational and transcontinental communities. Nevertheless, Africans in the Americas (North, Central, South and the Caribbean) have continually made wide-ranging and fundamental contributions to the societies in which they found themselves, with respect to economic development, language, music, culinary arts, religion, and literature, while retaining their distinct identities (Walker, 2001). Such contributions, despite limited recognition, were equally substantial in mathematics, various sciences, technology, medicine, and engineering (Van Sertima, 2007). And according to the economist, Lisa D. Cook, among African American inventors in the 19th and early 20th centuries, this occurred in large part, through the development of their own social networks to boost innovative outcomes, (Cook, 2011).

In an analogous manner, the concept of an Indian Oceanic world has been used to understand the relationships between the Indian sub-continent and its Diaspora. From an innovation perspective, Hobday (1995) has argued that beyond the ‘flying geese model’ explanation for East Asia’s development, overseas Chinese models that are reliant on strong familial and wider social relationships (or *guanxi*) offer a better account of autonomously-driven or endogenous innovation.

3. Conceptual Framework: Endogenous Innovation

Our attempt thus far has been to identify some anchors for a more expansive, yet more grounded discourse on endogenous innovation. Indeed, the broader perspective on innovation systems (as opposed to the narrow, science and technology focused one) recognises the importance of social, cultural and historical factors in properly directing technological capabilities towards inclusive and sustainable outcomes in the Global South (Arocena & Sutz, 2020; Lundvall et al., 2009). Our present contribution therefore gives more explicit voice to the deeper knowledge heritage of those societies themselves as the starting point for engaging with additional perspectives on innovation and development. Nevertheless, rather than being essentialist, we instead propose ‘endogeneity’ as a referential, self-critical, dialogical and evolving matrix of interaction with diverse forms of knowledge.

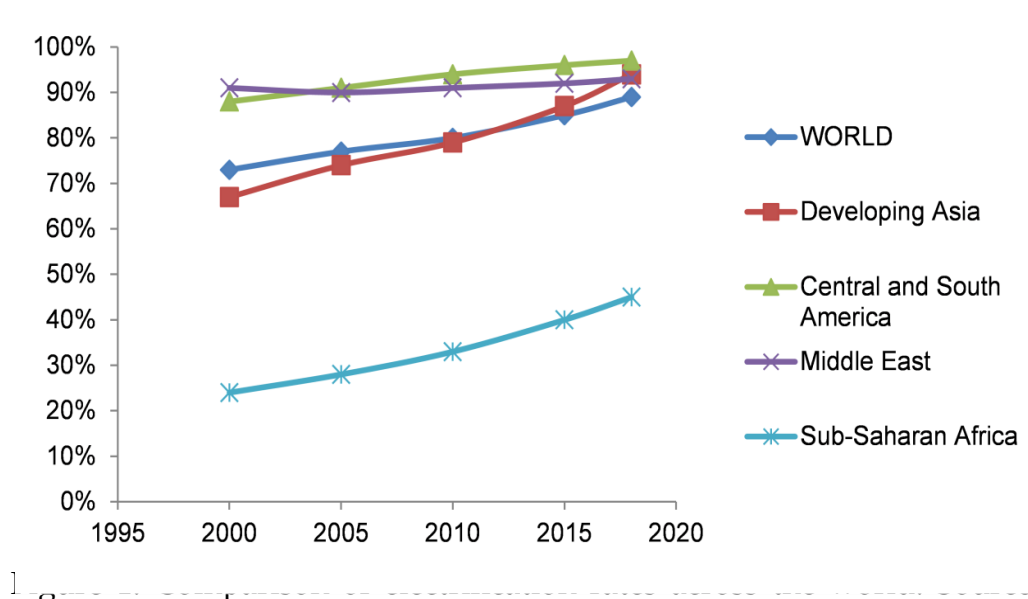
3.1 *Inclusive Catch-Up and Secondary Innovation*

In light of the emphasis on inclusive socio-economic and environmentally sustainable outcomes in contemporary development discourses, there has been some ambivalence about the relevance of the notion of innovation for economic catch-up for various reasons. For instance, Djeflat (2017) prefers the term ‘take off’ because he views catching up as a premature ambition for late industrialising economies that are characterised by little and ineffective R&D, low industrial productivity, and outdated technological and organisational strategies. For their part, Arocena and Sutz (2020) reject the term ‘catch-up’ in favour of ‘sustainable human development’ because in their assessment, catching up with the Global North would make it impossible to either reverse inequality or achieve environmental sustainability in the South. Conversely, however, Lee et al. (2015) have argued that Africa, in particular, has even more windows of opportunity for catching up than upper income Asian countries had, given the widespread emergence of industries such as that of information and communication technologies (ICTs). Lee, Juma and Mathews therefore recommend a diversity of catch-up strategies, which are adapted to market sizes, intra-African trade, and are aligned with sustainable development imperatives.

More recently, Kruss (2021), perceiving South Africa as being caught in the ‘middle income trap’, sees that as both a cause and a consequence of inequality in the country. Glenda Kruss therefore proposes the formation of ‘upgrading coalitions’ to achieve catch-up for inclusive development. Our assessment of the merits of both sets of arguments leads us to adopt a qualified version of catching up, which we refer to as - ‘inclusive catch-up’. We define this concept as closing the gap in desired human development outcomes, relative to an identified reference

society, a specified target, or a given date, and at a faster rate than had previously been achieved. Furthermore, we are convinced that the concept of secondary innovation, which has been theorised as a pathway for catching up in China by Wu, Ma and Xu (2009) and Wu and Li (2015), is actually grounded in an inclusive, Confucian outlook (Wu et al., 2020). This enables the classification of secondary innovation as a category of endogenous innovation at the firm level, national level, and in a civilisational perspective, respectively. At the level of the firm, secondary innovation proceeds in stages from duplicative imitation (with a focus on the operation of an adopted, foreign technology); to creative imitation (with a focus on its localisation); to exploitative innovation (with its focus on its differentiation); and to explorative innovation (with a focus on value innovation from new products) (Wu, Ma, Shi, et al., 2009).

However, from an inclusive catch-up perspective, the traditionally expected outcomes of novel products in a market (i.e. profitability and economic growth) can also be explicitly characterised in terms of indicators of human development. Examples may include universal access to potable water, improved sanitation, sustainable energy, affordable Internet services, the reduced incidence and ultimate eradication of certain diseases, etc. For instance, Figure 1 below shows the evolution of access rates to electricity in world regions, which suggests a need for Sub-Saharan Africa, in the aggregate sense, to close the gap with either the global average, or with the objective of universal access.



Soumonni and Ojah (2022, p. 2)

The figure above shows an incremental increase in the electrification rate of Sub-Saharan Africa, and more significantly, that the gap between it and the world's average has been constant over the last two decades, at least. An increasing level of competence with respect to secondary innovation in clean energy technologies could then be mobilised to increase the rate of electrification such that universal access can be achieved by 2030 (the date set by the UN Sustainable Development Goals) or another date set nationally or regionally. In this case, 'inclusive catch-up' encompasses the urgency of not 'falling behind' technologically and economically, but subordinates that to sustainable human development. Thus, the following heuristic on catching up inclusively offered by Ki-Zerbo (1993, p. 19) is apt: *'It's all very well to move fast as long as you know where you're going'*.

3.2 Secondary Innovation as a Bi-Directional Phenomenon

Secondary innovation is an approach to catching up that ultimately seeks to achieve original or R&D-driven innovation in a particular industry, which is new to the world, rather than imitative. Nevertheless, given that the framework is open and evolving, this makes it favourable to bi-directionality¹ the main provisos being that the overall trend is towards greater originality and that the rate at which inclusive outcomes are met is faster than the rate at which the target itself changes.

Furthermore, in light of the health care resource constraints in Zimbabwe that were accentuated by COVID-19, Dandara et al. (2021) suggest that ancestral and community-based knowledge of medicinal plants in Africa be further investigated using pharmacogenomics (involving human genome mapping) and molecular targeted therapeutics - a method that they refer to as 'precision herbal medicine'. The fruitfulness of such an approach can be appreciated in the exemplary work of Youyou Tu, the Nobel Prize-winning Chinese phytochemist, who led the development of the plant-based, anti-malarial drug, artemisinin (or *qinghaosu*) by successfully drawing on the writings of the 4th Century ACE philosopher and physician, Ge Hong (Tu, 2011). At the onset of the COVID-19 pandemic, Tu and her collaborators called for malaria-endemic countries to stock their medical facilities with artemisinin-based therapeutics and malaria diagnostics, in addition to the infection management protocols for the pandemic, in order to boost their overall preparedness without undermining the fight against malaria (Wang et al., 2020).

Thus, we argue that grassroots innovation can play an important role in the generation of endogenous knowledge, its production at the relevant scale, the implementation of preventive measures, and in the promotion of non-pecuniary and socially-inclusive outcomes. Indeed, Sheikh and Bhaduri (2020) have shown

that a number of inventions by artisans in Kashmir, which were put to productive use, were fundamentally motivated by values, such as the preservation of culturally-based techniques, better health, improved social embeddedness, and simply more time to rest. A recent study of endogenous pharmaceutical innovation in South Africa and Benin by Soumonni and Sègla (2021) also identified knowledge holders of herbal medicine (grassroots innovators) who were working with laboratories during the pandemic to improve the precision of their proposed therapeutic remedies. Together, they formed an epistemic community united by common values, a shared philosophical outlook, and collective objectives. In this sense, knowledge development that emerges in response to local challenges can be of universal relevance, and knowledge with broad applicability can be revised in the face of more site-specific considerations.

Even more decisive, however, is the innovative deployment and diffusion of secondary innovation to satisfy an existing demand – or tertiary innovation, whose effectiveness is primarily driven by business model innovation or an analogous organisational innovation. Nevertheless, in its technological dimension, we extend the insight by Soumonni and Ojah (2022), who refer to domestic ICT capabilities (corresponding to secondary innovation) that enable the significantly more rapid diffusion of vital services (namely, energy), as constituting the basis for tertiary technological innovation. In the context of COVID-19, effective testing, contact tracing and even vaccine-related logistics benefited from novel software applications developed for those purposes. An excellent example of an innovative entrepreneur who brings all three tiers together is Khadidiatou (Khady) Sall, a Senegalese molecular biologist who founded an innovation lab in the city of Dakar, named Ubbil (meaning ‘open’ in the Wolof language), in which she spearheaded the manufacturing of 3D-printed face shields that were distributed to medical staff at 60 different hospitals during the COVID-19 pandemic (Powell, 2021). In a recent interview that she gave to the scientific journal, *Nature*, Khady Sall, who has also founded a non-profit science education organisation, stated her mission as follows:

‘Sustainable development has to be rooted in the culture, preserving local languages and integrating ancestral practices that are good for the environment. It has to resemble you and where you want your country to go. You can get there by being authentic and you can do that by teaching science in the local language, such as Wolof, a language of Senegal, Gambia and Mauritania.’ (Powell, 2022)

3.3 *The Innovative Society*

We have earlier underscored the need to contextualise the nation-state in many parts of the Global South in its own historical context, and in relation to contemporary challenges. In this vein, an incisive analysis by Krishna and Chandra (2019) of India's efforts at building an 'innovative society' - commensurate with Jawaharlal Nehru's grand vision of eradicating poverty through science - driven by its world class Indian Institute of Technology (IIT) system, is highly instructive for the remainder of the hemisphere. We also note that especially for polities in which socio-economic inequality and environmental problems are on the rise, Freeman (2002) had suggested that the appropriate innovation systems would need to leverage social solidarity, engender enlightenment, and ultimately prioritise well-being over economic competitiveness. Building upon these scholars' insights, we offer a definition of the 'innovative society' as a purposive coalition of actors that is animated by the imperative of self-directing or endogenous innovation. It is informed by a restorative ideal, which through a critical retrieval of ancestral values, can be brought to bear in the building of just and sustainable societies. This notion of critical retrieval is embedded in a philosophical concept among the Akan people of present-day Ghana and Côte d'Ivoire, which is known as *Sankofa*.

In order to address this diversity of actors, the 'innovative society' dimension of our framework equally cuts across state agencies, private firms and grassroots organisations. In instances of weaker states, trust-based social network ties, both loose and strong, may anchor the formation of such a society. This core understanding as a starting point for thinking about a more effective supra-national African society (grounded in a civilisational outlook), which could in turn, better interact with the Chinese civilisational state with respect to innovation-based economic relations, has been elucidated by Soumonni (2018).

The schematic below now depicts our overall conceptual framework. It does so in a transversal or cross-cutting perspective along three dimensions, which we subsequently explain.

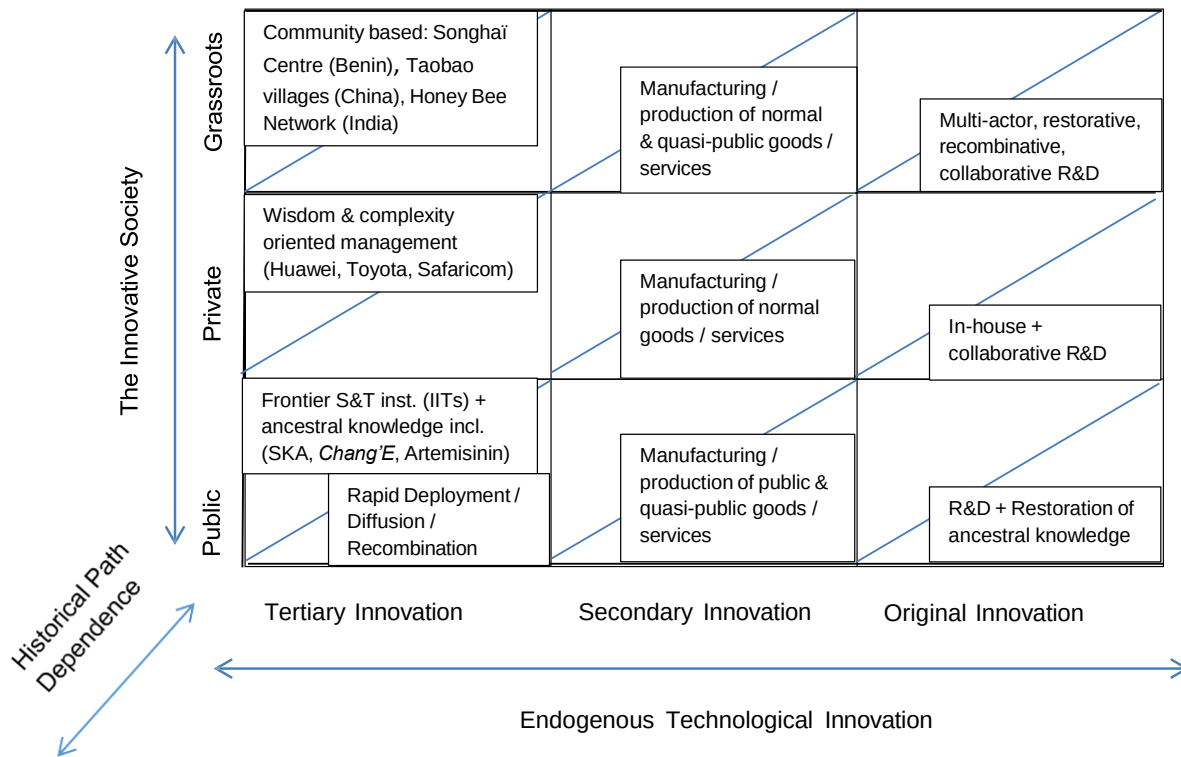


Figure 2 Endogenous Innovation in Transversal Perspective

In Figure 2, the first dimension (x-axis) is a categorisation of endogenous technological innovation based on original, secondary and tertiary innovation in a bi-directional manner. The second dimension (y-axis) identifies three main institutional actor categories, and represents a historically informed 'innovative society' that is a subset or sub-network within a wider territory or polity, as well as the actors' transnational innovator networks. However, even though we acknowledge that original, secondary and tertiary innovation each contain both components, the x-axis in our framework emphasises the technological component of these categories of endogenous innovation. Thus, while the two broad components are mutually constitutive in practice, for analytical purposes, orthogonality between the x- and y-axes enables us to separately assess the various organisational anchors within the innovative society that could best deploy various forms of endogenous technological innovation.

These two traditional dimensions produce a 3 x 3 matrix with nine possible institutional actor/technological innovation pairs that can be recombined with each other to identify feasible paths to achieve given inclusive innovation outcomes. Our illustrative examples offer some direction in relation to actors, the character of their technological capabilities, and the nature of goods and services they may produce. The third dimension (z-axis), historical path dependence, then requires the analyst to reflect on the antecedents of the first two dimensions in a given environment in order to identify the innovation capabilities that are sufficiently endogenous, and the institutional actors that are most likely to deploy them to the desired ends.

3.4 Historical Path Dependence

As can be expected, the interpretation of historical events from the distant past, or more recent ones for that matter, engenders disagreements, even among those with the requisite skills. Nevertheless, to aid in our sense-making beyond drawing on sources of the highest scholarly repute, we are guided by some broad principles. In the first instance, we adopt the approach articulated by Thapar (2016), which rejects the arbitrary bifurcation between the 'civilised' and the 'primitive' typically introduced to legitimise conquest (or other exploitative advantages), in favour of inclusive perspectives. Another precept, in addition to very specific methodological recommendations for specialists, is offered by Ki-Zerbo (1990, p. 1), who writes that:

'...the history of Africa, like the history of mankind as a whole, is really the story of an awakening. That story needs rewriting, for it has been considerably distorted by ignorance or self-interest.'

An example of such a distortion can be observed in a tribute to the noted sinologist and historian of science, Joseph Needham, by the sociologist of science, Steve Fuller. In assessing the manner in which the history of science might inform diverse socio-political objectives, Fuller reduces the book entitled *Civilization or Barbarism* by Cheikh Anta Diop (1991), a renowned African scientist and historian, to 'a rhetoric of the 'stolen legacy' (Fuller, 2001, p. 125) (the title of a separate book by another author). Yet, in his chapter entitled 'Africa's Contribution: Sciences', Diop (1991, pp. 231-307) reproduced portions of ancient mathematical texts such as the *Papyrus of Moscow* and the *Rhind Papyrus*, and translated them directly. This included an explicit demonstration from the *Berlin Papyrus* of the right triangle theorem that would much later come to be known as the Pythagorean theorem (Diop, 1991, pp. 258-260). He did this work independently, based on his training in the Ancient Egyptian language, as well as his expertise in the natural sciences (obtained, parenthetically, at the most select institutions in France). As such,

Fuller's perfunctory treatment of Diop's own work, strictly speaking, is wholly unjustified.

Given this caveat about the need for constant vigilance against internalising prejudices from an external gaze, the dimension of historical path dependence informs the first two dimensions of our framework with respect to existing competences that are likely to be deployed by specific actors. It can do so by highlighting historical experiences that could inspire contemporary efforts, as a source of insightful technical knowledge, to revive aspects of societal arrangements that may still be useful, or all three. With respect to medicinal innovation, for instance, the African American viral immunologist, Dr Kizzmekia 'Kizzy' Corbett, who co- designed the molecular structure for the first vaccine made by Moderna at the US National Institutes of Health (NIH), credits a cultural value encapsulated in the African American proverb, 'each one teach one', for inspiring her to persist during her own training, and to mentor younger scientists from similar backgrounds (Corbett, 2020). This corroborates the strategic importance of 'folk wisdom' in the resilience of Japanese firms during the COVID-19 pandemic (Nonaka & Takeuchi, 2021); of socio-cultural networks for African American inventors (Cook, 2011); of the Zimbabwean scientific Diaspora for precision herbal medicine in its country of origin (Dandara et al., 2021); and of *guanxi* social relationships in East Asia (Hobday, 1995). All these have analogous implications for Diasporic communities with linkages in the Global South, when adequately cultivated.

With respect to which actors in the 'innovative society' could contribute to endogenous innovation, the exceptionally comprehensive and insightful review of the first 75 post- independence years of Indian science, technology and innovation (STI) policy by V.V. Krishna (2021) reveals that despite impressive accomplishments in science-driven innovation, including the independent development of two domestic vaccines (original innovation) and the manufacturing of two others (secondary innovation), the informal sector in India nevertheless constitutes 'more than 95% of the total labour force, about 550 million' (Krishna, 2021, p. 1). A similarly instructive study by Saradindu Bhaduri and his co-authors finds that due to political and historical antecedents, strong IPR regimes being implemented in impoverished countries, in particular, lead to adverse human development outcomes, whereas improving those outcomes first, appears to have a favourable effect on IPRs (Bhaduri et al., 2015). In such contexts then, research that emphasises low cost, socially-inclusive and grassroots innovation can be systematically brought to bear in meeting vital needs by starting with the knowledge held by the communities themselves (Muchie et al., 2017).

4. Towards a South-South Endogenous Innovation Paradigm

To conclude, in this paper, we propose an expanded understanding of endogenous innovation in the Global South, which is anchored in deeply rooted historical, philosophical, cultural, and economic (or civilisational) perspectives, and in a critical exchange with the developmental imperatives of the present. We propose an exploratory conceptual framework, underpinned by three succinct dimensions that can enable researchers and policy-oriented actors to better search for opportunities for endogenous innovation on the basis of empirical evidence.

However, we acknowledge that elaborating a robust research agenda along the lines of our proposed framework would require a diversity of research skills that can best be harnessed through multi- and transdisciplinary teams. More in-depth studies with well-specified hypotheses will also be required to better guide praxis. For instance, the medical pioneers in Ancient Egypt, Imhotep and Peseshet, a female physician, are still favourably referred to in some contemporary scientific journals as symbols of erudition and commitment to social welfare in classical antiquity. Analogous outlooks currently characterise the philosophical reflections that have accompanied the Chinese lunar missions, *Chang'E* 1, 2, 3, 4 and 5 (*Chang'e* being the ancient goddess of the moon), and the 'Shared Sky' Aboriginal art exhibitions associated with the Square Kilometre Array (SKA) radio telescopes in Australia and South Africa. Similarly, a reconsideration of Abu Shaker and Shaykh Bakri Sapalō, promoters of syncretic astronomy in Ethiopia, seven centuries apart, could serve a similar role with respect to modern astronomy in the country. Such innovative activities can serve to reinvigorate the cultural imaginary of these societies with respect to contemporary sciences, and are a manifestation of what we term 'endogenous modernity'. Future work will seek to specify how, through a genuine civilisational dialogue within the Global South, as well as between South and North, various societies can galvanise inclusive catch-up (and post catch-up) efforts in sustainability transitions, equitable digital innovation, inclusive astronomy and more, beyond the COVID-19 pandemic.

References

- Arocena, R., & Sutz, J. (2020). The need for new theoretical conceptualizations on National Systems of Innovation, based on the experience of Latin America. *Economics of Innovation and New Technology*, 29(7), 814-829. <https://doi.org/10.1080/10438599.2020.1719640>
- Bagchi, A. K. (2015). On Colonialism and the Indian Economy. *Review of Agrarian Studies*, 5(2), 95-109.
- Bhaduri, S., Francis, D. J., Dutt, D., Kumar, V., & Sheikh, F. A. (2015). Politico-Historical Contingencies, Intellectual Property Rights, and Economic Performance Across Countries: A Simultaneous Equation System Perspective. *The Journal of World Intellectual Property*, 18(3-4), 107-126. <https://doi.org/10.1111/jwip.12034>
- Cook, L. D. (2011). Inventing social capital: Evidence from African American inventors, 1843-1930. *Explorations in Economic History*, 48(4), 507-518. <https://doi.org/10.1016/j.eeh.2011.05.003>
- Corbett, K. (2020). The duty to mentor, be visible and represent. *Nature Medicine*, 26(11), 1670-1670. <https://doi.org/10.1038/s41591-020-1122-y>
- Dandara, C., Dzobo, K., & Chirikure, S. (2021). COVID-19 pandemic and Africa: from the situation in Zimbabwe to a case for precision herbal medicine. *OMICS: A Journal of Integrative Biology*, 25(4), 209-212. <https://doi.org/10.1089/omi.2020.0099>
- Diop, C. A. (1991). *Civilization or Barbarism* (Y.-L. M. N. Ngemi, Trans.; H. J. Salemson & M. de Jager, Eds.). Lawrence Hill Books.
- Djeflat, A. (2017). Emerging innovation systems (EIS) and take-off issues in North African economies: evidence from Algeria. In *Research Handbook on Innovation Governance for Emerging Economies*. Edward Elgar Publishing.
- Freeman, C. (2002). Continental, national and sub-national innovation systems - complementarity and economic growth. *Research Policy*(31), 191-211.
- Fuller, S. (2001). Prolegomena to a World History of Science. In S. I. Habib & D. Raina (Eds.), *Situating the History of Science: Dialogues with Joseph Needham* (pp. 114-151). Oxford University Press.
- Getachew, A. (2020). *Worldmaking After Empire: The Rise and Fall of Self-Determination*. Princeton University Press.
- Gosling, D. L. (2007). *Science and the Indian Tradition: When Einstein Met Tagore*. Taylor & Francis.
- Gu, S., & Lundvall, B.-Å. (2006). Introduction: China's innovation system and the move towards harmonious growth and endogenous innovation. *Innovation*, 8(1-2), 1-26. <https://doi.org/10.5172/impp.2006.8.1-2.1>
- Gu, S., Schwaag Serger, S., & Lundvall, B.-Å. (2016). China's innovation system: ten years on. *Innovation*, 18(4), 441-448. <https://doi.org/10.1080/14479338.2016.1256215>
- Habib, I. (1975). Colonialization of the Indian Economy, 1757 - 1900. *Social*

- Scientist*, 3(8), 23-53. <https://doi.org/10.2307/3516224>
- Hobday, M. (1995). Innovation in East Asia: Diversity and development. *Technovation*, 15(2), 55-63. [https://doi.org/https://doi.org/10.1016/0166-4972\(95\)96610-6](https://doi.org/https://doi.org/10.1016/0166-4972(95)96610-6)
- Inikori, J. E. (2002). *Africans and the industrial revolution in England: a study in international trade and economic development*. Cambridge University Press.
- Ki-Zerbo, J. (1990). General Introduction. In J. Ki-Zerbo (Ed.), *UNESCO General History of Africa, Vol. I, Abridged Edition: Methodology and African Prehistory* (pp. 1-9). University of California Press.
- Ki-Zerbo, J. (1992). Le développement clés en tête. In J. Ki-Zerbo (Ed.), *La natte des autres: Pour un développement endogène en Afrique* (pp. 1-71). CODESRIA.
- Ki-Zerbo, J. (1993). The universal and the particular. *UNESCO Courier*, (December 1993), 18-20.
- Krishna, V. V. (2021). India@ 75: Science, Technology and Innovation Policies for Development. *Science, Technology and Society*, 1-34. <https://doi.org/10.1177/09717218211047029>
- Krishna, V. V., & Chandra, N. (2019). Educating for the Innovative Society: The Role of Indian Institutes of Technology in India. In G. Redding, A. Drew, & S. Crump (Eds.), *The Oxford Handbook of Higher Education Systems and University Management* (pp. 414-431). Oxford University Press.
- Kruss, G. (2021). Catching up, falling behind: the need to build upgrading coalitions for innovation and inclusive development in South Africa. *Nova Economia*, 30, 1115-1144. <https://doi.org/10.1590/0103-6351/6191>
- Lee, K. (2016). *Economic Catch-up and Technological Leapfrogging: The Path to Development and Macroeconomic Stability in Korea*. Edward Elgar Publishing, Incorporated.
- Lee, K., Juma, C., & Mathews, J. (2015). Innovation capabilities for sustainable development in Africa. In C. Mongo & J. Y. Lin (Eds.), *The Oxford Handbook of Africa and Economics, Volume 2: Policies and Practices* (pp. 272-286).
- Lewin, A. Y., Välikangas, L., & Zhang, Y. (2020). Commentary on Chapter 1, "The Management Transformation of Huawei: An Overview" by Johann Peter Murmann In X. Wu, J. P. Murmann, C. Huang, & B. Guo (Eds.), *The Management Transformation of Huawei: From Humble Beginnings to Global Leadership* (pp. 52-69). Cambridge University Press.
- Lundvall, B.-Å., Joseph, K. J., Chaminade, C., & Vang, J. (2009). Innovation system research and developing countries. In B.-Å. Lundvall, K. J. Joseph, C. Chaminade, & J. Vang (Eds.), *Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Setting* (pp. 1-30). Edward Elgar Publishing.
- Malerba, F., & Orsenigo, L. (1995). Schumpeterian patterns of innovation *Cambridge Journal of Economics*, 19(1), 47-65.
- Muchie, M. (2004). Resisting the Deficit Model of Development in Africa: Rethinking through the making of an African National Innovation System. *Social Epistemology*:

- A Journal of Knowledge, Culture and Policy*, 18(4), 315-332.
<https://doi.org/10.1080/0269172052000343321>
- Muchie, M., Bhaduri, S., Baskaran, A., & Sheikh, F. A. (2017). *Informal Sector Innovations: Insights from the Global South*. Taylor & Francis.
- Nonaka, I., & Takeuchi, H. (2021). Humanizing strategy. *Long Range Planning*, 54(4), 102070. <https://doi.org/10.1016/j.lrp.2021.102070>
- Oyewumi, O. (Re)Centring African Epistemologies: An Intellectual Journey. *CODESRIA Bulletin Online*(3), 1-4.
<https://journals.codesria.org/index.php/codesriabulletin/article/view/1973>
- Powell, K. (2021). How junior scientists can land a seat at the leadership table. *Nature* 592, 475-477. <https://doi.org/10.1038/d41586-021-00956-6>
- Powell, K. (2022). Rooting African science and technology education in cultures and languages. *Nature* 603, 187-188. <https://doi.org/10.1038/d41586-022-00449-0>
- Radice, W. (1998). Particles and sparks: Tagore, Einstein and the poetry of science. *India International Centre Quarterly*, 25(2/3), 131-150.
<http://www.jstor.org/stable/23005686>
- Reinert, H., & Reinert, E. S. (2006). Creative Destruction in Economics: Nietzsche, Sombart, Schumpeter. In J. Backhaus & W. Drechsler (Eds.), *Friedrich Nietzsche (1844-1900): Economy and Society* (pp. 55-85). Springer US.
- Schumpeter, J. A. (2003). *Capitalism, Socialism and Democracy*. Routledge. (1943)
- Sheikh, F. A., & Bhaduri, S. (2020). Grassroots innovations in the informal economy: insights from value theory. *Oxford Development Studies*, 48(1), 85-99.
<https://doi.org/10.1080/13600818.2020.1717453>
- Soumonni, O. (2018). Locating the "Nation" in African Innovation Systems: Implications for Africa-China Economic Relations. In K. D. L. S. Prah & V. Gumede (Eds.), *Africa-China Partnerships and Relations* (pp. 141-169). Africa World Press.
- Soumonni, O., & Ojah, K. (2022). Innovative and mission-oriented financing of renewable energy in Sub-Saharan Africa: A review and conceptual framework. *WIREs Energy and Environment*, 11(1), e416
<https://doi.org/https://doi.org/10.1002/wene.416>
- Soumonni, O., & Sègla, A. (2021). Endogenous Pharmaceutical Innovation in the Era of COVID-19: Epistemological Perspectives from Benin and South Africa. (UJ-TRCTI Working Paper Series WP 2021-08. University of Johannesburg: South Africa).
https://www.uj.ac.za/wp-content/uploads/2022/05/wp8-soumonni_final.pdf
- Tagore, R. (1994). Brahmā, Visnu, Śiva (W. Radice, Trans.). In R. Tagore (Ed.), *Selected Poems*. Penguin Books.
- Thapar, R. (2001). History of Science and the *Oikumene*. In S. I. Habib & D. Raina (Eds.), *Situating the History of Science: Dialogues with Joseph Needham* (pp. 16-28). Oxford University Press.
- Thapar, R. (2016). *Indian Society and the Secular: Essays*. Three Essays Collective.
- Tu, Y. (2011). The discovery of artemisinin (qinghaosu) and gifts from Chinese

- medicine. *Nature Medicine*, 17(10), 1217-1220. <https://doi.org/10.1038/nm.2471>
- Van Sertima, I. (Ed.). (2007). *Blacks in Science: Ancient and Modern*. Transaction Publishers. (1983).
- Visvanathan, S. (2013). The Dreams of Reason: Rabindranath Tagore and the Invention of Science in India. *Economic and Political Weekly*, 48(47), 43-49. <https://www.jstor.org/stable/23528641>
- Walker, S. S. (Ed.). (2001). *African Roots/American Cultures: Africa in the Creation of the Americas*. Rowman & Littlefield Publishers.
- Wang, J., Xu, C., Wong, Y. K., He, Y., Adegnik, A. A., Kremsner, P. G., Agnandji, S. T., Sall, A. A., Liang, Z., Qiu, C., Liao, F. L., Jiang, T., Krishna, S., & Tu, Y. (2020). Preparedness is essential for malaria- endemic regions during the COVID-19 pandemic. *The Lancet*, 395(10230), 1094-1096.
- Wu, X. (2020). Preface. In X. Wu, J. P. Murmann, C. Huang, & B. Guo (Eds.), *The Management Transformation of Huawei: From Humble Beginnings to Global Leadership* (pp. xii-xvi). Cambridge University Press.
- Wu, X., & Li, J. (2015). Towards an Innovation-driven Nation: The 'Secondary Innovation' Framework in China. *STI Policy Review*, 6(1), 36-53.
- Wu, X., Ma, R., Shi, Y., & Rong, K. (2009). Secondary innovation: the path of catch-up with 'Made in China'. *China Economic Journal*, 2(1), 93-104. <https://doi.org/10.1080/17538960902860147>
- Wu, X., Ma, R., & Xu, G. (2009). Accelerating secondary innovation through organizational learning: A case study and theoretical analysis. *Industry and Innovation*, 16(4-5), 389-409. <https://doi.org/10.1080/13662710903053656>
- Wu, X., Murmann, J. P., Huang, C., & Guo, B. (Eds.). (2020). *The Management Transformation of Huawei: From Humble Beginnings to Global Leadership*. Cambridge University Press.
- Yai, O. (2008). Africa, African Diaspora and the Prospect of Global Cultural Dialogue. *India International Centre (IIC) Occasional Publication*; 2. https://iicdelhi.in/sites/default/files/2020-11/OP_No_2.pdf

Notes

¹ We acknowledge one of our anonymous reviewers for encouraging us to pursue this line of thought.

Indigenous Technology, Innovation and Inclusive Development: A Study of the Silk Reeling Sector of Jammu and Kashmir

Priyanka Sharma
University of Delhi, India



Abstract

The current paper explores the potential of the incorporation of indigenous technology, composed of local knowledge, into the design of advanced technologies and developmental policy. It argues that if the technological innovation is informed by indigenous knowledge and local technology, it can lead to innovation of an appropriate advanced technology. Exploring how these knowledge systems have existed for long periods of time, remained dynamic, and are now adapted to the contemporary, can possibly provide a new way to a sustainable development paradigm.

At the empirical level, this paper analyzes the indigenous technology used and the technological progress that has happened in the silk reeling sector of silk industry of Jammu and Kashmir, a state in northern India.

It is an exploratory study and a qualitative research design has been employed. Both primary and secondary sources have been used, with the primary data collected primarily through detailed semi-structured interviews, non-participant observation, and informal conversations. The fieldwork is the most significant and crucial aspect. This study is based on a two-year (2020 and 2021) field work research on the silk Industry of Jammu and Kashmir.

It is argued in the paper that the revival and revitalization of traditional technology in the silk reeling sector and its syncretism with the modern technology will lead to more equitable and sustainable development. If innovation is informed by the sustainable knowledge, which is a blend of scientific, professional and local knowledge, it has the potential to lead to a locally appropriate sustained growth of the silk industry of Jammu and Kashmir. I referred to this process as 'epistemic syncretism', where there is a plurality of knowledge and all knowledge systems are given their due cognitive validity.

Key Words: Cognitive Justice. Epistemic Syncretism, Indigenous Knowledge, Indigenous Technology, Innovation, Sustainable and Inclusive Development, Silk Industry, Silk reeling

1. Introduction

The fault lines in the 21st-century development model are clearly visible. The current development paradigm is neither viable nor desirable. It has failed to deliver equitable and sustainable growth. After decades of spreading the concept of “development,” only a few countries can be called “developed,” while others struggle to emulate them at enormous ecological and social cost. The issue is not one of insufficient implementation but of viewing development as linear, unidirectional material and economic growth (Damaria and Kothari, 2017). Development was initially looked at as a very unilateral concept with only an economic connotation. This excessive obsession with economic growth and the GDP eventually attracted criticism and the need for broadening its definition and linking it more with the overall well-being of the real wealth of a nation, the people was highlighted (Deb, 2009; Sanyal, 2014). According to Vandana Shiva, the present development model has destructed the life of society and failed to respect the limits of the earth. It is so because under the current scenario the 1 percent of the global population controls all the sources of livelihood and the wealth of the rest of 99 percent of the population (Kothari, Salleh, Escobar, Demaria & Acosta, 2019). Inequalities of the past have taken a brutal form and this paradigm has failed to take cognizance of the destruction of nature and society. This model is backed by the hegemonized modernist knowledge paradigm associated with science and technology and the economic connotation of development, often regardless of how relevant or closely connected it may be to the developmental problems of the regions to which it is applied. The present harsh realities of global warming, massive environmental degradation, and an increasing rich-poor divide are driving the world to seek a solution. Many alternatives have been proposed by various scholars. This includes *Buen Vivir*, a way of living with numerous names and varieties in different parts of South America; *Ubuntu*, which emphasizes human mutual recognition in South Africa and several other African countries; and *Swaraj*, which emphasizes self-reliance and self-governance in India (Kothari et al., 2019).

The search for alternatives to the current development model can possibly be located in indigenous knowledge systems (IKS)¹ or what used to be referred to variously as ‘already existing knowledge systems (AEKS),’ ‘traditional knowledge,’ ‘local knowledge,’ ‘folk knowledge,’ ‘people's knowledge,’ and ‘traditional wisdom.’ These knowledge systems are locally developed and are in harmony with nature, specific to a society or culture (Banerjee, 2021). Communities generate and transfer this knowledge over time in order to deal with their own agro-ecological and sociopolitical situations (Fernandez, 1994). These knowledge systems are created through a process of analyzing local context, experimenting with strategies, and then re-adapting already recognized solutions to new environmental, socio-cultural, and technical

circumstances (Brouwers, 1993). Indigenous knowledge has a lot to teach us about achieving the goal of Sustainable Development. Global social injustice is primarily epistemological in nature, and global social justice cannot exist in the absence of global cognitive justice (Santos, 2007). It is critical for sustainable development that the development model be supported by sustainable knowledge. A sustainable knowledge base is established through high-quality, locally contextualised research. It pertains to a synthesis of scientific, professional, and local knowledge. Local knowledge usually deals with the same areas as scholarly research. However, local knowledge embodies different perspectives and understandings that are informed by the local context (Nugroho et al, 2018).

Exploring how these indigenous knowledge systems have existed for very long periods of time, remained dynamic, and have now adapted to the contemporary, can possibly provide a new way to a sustainable development paradigm (Banerjee, 2021). Despite significant efforts to catalogue and document indigenous knowledge systems, little attention have been paid to the scientific rationale and technological content of these systems (Tharakan, 2017). These indigenous and traditional knowledge systems are used to build tools in order to solve practical problems. Indigenous technology refers to the technological knowledge, skills, and resources passed down from earlier indigenous people to today's descendants in order to meet their requirements and wants through the investigation, design, development, and evaluation of products, processes, and systems with the goal of solving practical problems (Gumbo, 2014). It is an important part of the cultural heritage. Many of these indigenous technologies may be appropriate for equitable and inclusive development because they are informed by and focus on the basic needs of the local context in which they have evolved. In order to integrate indigenous technology into advanced technological innovation and development, it must be explored, analysed, and validated.

1.4 Silk Industry of India

India is well-known for its indigenous knowledge systems, which include textiles, Ayurveda, metalwork, and precious stone crafts, among other things. These knowledge systems have high relevance to India's rural economy. It is one of India's oldest and most important textile industries. It is not just an industry or a fabric but an inseparable part of Indian culture and way of life. Silk production is a labor intensive agro-based practice that dates back to several centuries (Priyanka, 2021). Today, India is the second-largest producer of silk in the world and enjoys the unique distinction of producing all four kinds of silk. This industry, from farm to fabric, employs around 8.5 million people in India (Central Silk Board, 2022). The top five silk producing states in India are Karnataka, Andhra Pradesh, Tamil Nadu, West Bengal, and Jammu and Kashmir (J&K), which account for 98% of the total mulberry raw silk

production in India. In this paper, at the empirical level, the silk reeling sector of the silk industry of Jammu and Kashmir will be analyzed.

1.4.1 Silk Industry of Jammu and Kashmir

Jammu and Kashmir has a longstanding and glorious past associated with the silk industry. The silk industry of Kashmir goes far back in time and can be found in written records as early as the 7th century A.D. Also, Kashmir being a part of the ancient Silk Route around the 2nd century B.C. indicates the possibility of the industry being in existence for much longer. Over thousands of years, silk has become an inseparable part of culture. It is one of the traditional occupations in Jammu and Kashmir, employing mainly the rural population. This industry has been the backbone of J&K's economy. Jammu and Kashmir is the only traditional silk-producing state in India that is capable of producing bivoltine silk comparable to the quality of silk imported in the international market. The climate of J&K is congenial for rearing both 'univoltine' and 'bivoltine' silkworm species for cocoon production. These cocoons are far superior to the 'multivoltine' ones produced in the rest of India. Jammu and Kashmir is the only region of India that is at the same altitude as the leading bivoltine silk producing countries of the world. Also, Jammu and Kashmir has variable agro-climatic zones and cradles diverse mulberry genetic resources. There are four indigenous species of mulberry. Jammu and Kashmir is the only region in the country where all these four species can be found. According to the Central Silk Board of India, sericulture provides a means of livelihood to more than 30,000 rural families in J&K. It is practiced as an important subsidiary occupation for livelihood in almost all 20 districts. The majority of these families are from the weaker sections of society, such as Scheduled Castes, Scheduled Tribes, Landless, and other low-income rural people, with a majority of female folks. This industry has huge income and employment generation potential in rural areas. It is best suited for small and marginal farmers, as only a small land holding is required to rear silkworms. Furthermore, sericulture is a labor-intensive industry, with women accounting for 60% of the workforce. As a result, it is best suited for an economy with surplus labor and may also be instrumental in women's empowerment.

However, it is discouraging that the silk industry of Jammu and Kashmir, which has seen a glorious past, is on the decline while a large section of the population continues to be dependent on it. According to the Sericulture Policy 2020 of J&K, the mulberry silk production of J&K accounts for only 0.66% of the total mulberry silk production of India. During the Maharaja's rule, this industry used to be the main source of revenue, but today it has turned into a non-priority sector. According to the Jammu and Kashmir state sericulture development department, there are 39 private silk reeling units, but 24 of them are non-functional. The government reeling units have also been shut down. The silk filature which was established in the Jammu division in 1909 and provided a source of livelihood for large section of population has become a

history now having been demolished in 2011 to make way for a multispecialty hospital. Sericulture land being grabbed and used for other infrastructure projects like flyovers, roads, railway lines, hospitals, and so on is resulting in the shrinking of sericulture. In spite of being such an important sector and a brilliant source of revenue, the silk industry of J&K is dying a silent death. Silk is an elite product in itself, but the farmers and artisans who are producing it are struggling to meet their ends.

1.5 Process of Silk Production

To understand the, it is imperative to understand the process of silk production and the various stages involved. This will contextualize the study and provide the required vocabulary to understand the argument presented further.

The entire gamut of silk production consists of multiple stages, which begin with nurturing silkworms and then processing the fibers they produce. It involves activities belonging to both agriculture and industrial sector. The agriculture sector activities comprises of mulberry cultivation in case of mulberry silk, silk worm rearing and disposal of cocoons. The industrial sector consists of all the post-cocoon activities like silk reeling and weaving

Table 1.1: Stages involved in the Silk Production

Stage		Description
Pre-Cocoon Agricultural activities	Moriculture: for mulberry silk	The cultivation process of mulberry is known as Moriculture, and it can be grown in various climatic conditions, ranging from temperate to tropical.
	Silk worm rearing:Cocoon production	Silk worm is reared and properly fed. From egg hatching to formation of cocoon takes around 40 to 50 days.
Post-cocoon Industrial activities	Silk Reeling: Raw Production	Raw silk is produced by extracting filaments from cocoons using various types of tools like hand charkha, country charkha, cottage basin, Multi-end Reeling, or Automatic Reeling technology.
	weaving: Silk Production	Silk fabric is weaved on hand or power looms using raw silk.

Silkworm rearing consists of following steps: The whole cycle from egg hatching to formation of cocoon takes around 40 to 50 days. However, it varies depending on the climatic conditions and race of silk worm (Singh, 2012; Narsaiah, 2019).

- **Incubation of Silk Worm Eggs:** The rearing of silkworm begins with the buying of silkworm eggs. These eggs are known as Disease Free Layings (DFLs) and are usually referred as seed. Then the hatching of the eggs is done and this process is known as seed incubation. Seed incubation is carried under controlled conditions for the uniform hatching of eggs. This process usually takes 9-10 days.

Figure 1: Un-hatched Silk Worm Eggs



Source: Author, Rajouri District of Jammu and Kashmir, March 10, 2020.

- **Feeding:** It is very important to feed the silkworms properly as it will affect the quality of silk. The mulberry silkworms feed on mulberry leaves only. The quality of leaves, its moisture and protein content is a deciding factor in the quality of silk that the worm will produce. As the size of larvae² increases its appetite also increases. The amount of feeding depends upon the race of silk worm (Ganga & Chetty, 1997). The larvae period consists of five instars³ and four moults⁴

Table 1.2: Table given below shows the time it takes to form cocoon.

Instars	Time (days)	Moult	Time (hours)
I	3-4	I	24
II	2-3	II	18
III	3-4	III	36
IV	4-5	IV	48
V	6-7		

Figure 2: The pictures given below are taken during the different instar and moulting periods.



Source: Author, Rajouri District of Jammu and Kashmir, April 7, 2020.



Source: Author, Rajouri District of J&K, April 18, 2020.

- Mounting And Spinning: After the last instar, larvae attain its full growth and start spinning cocoon for which they need a suitable place. Farmers shift the mature larvae to the mountages and this process of transferring is called Mounting. Traditionally farmers use dried grass and twigs in J&K to prepare mountages.

Figure 3: Following pictures taken during field study shows the mountages used and the spinning process.



The harvested cocoon is then sold in market and the reelers reel it to make silk yarn which is called raw silk. Further this raw silk is weaved into a fabric and final products are made out of it. With this the whole cycle completes.

In the following section, the indigenous technology used and the technological progress that has happened in the reeling sector of the silk industry of Jammu and Kashmir to cope with the influx of demand is explored to determine whether or not the incorporation of indigenous technology, informed by local knowledge, into the design and implementation of advanced technologies can lead to locally appropriate sustainable development of the industry.

1.5.1 Silk Reeling

Reeling is one of the initial activities in the post-cocoon silk production process. It is a critical link in the process of transformation of an agricultural product, cocoons, into an industrial output, the yarn (Badu, 2019). It is the intermediate phase and holds an interesting position in the chain because it is regarded as ritually and physically unclean and polluting, whereas the stages preceding and following it are not (Joseph, 2018). Silk reeling consists of a number of activities: cocoon sorting⁵, stifling, cooking, reeling, re-reeling and twisting. In this stage the unwinding of silk filaments from the cocoons is done (Das, 1992; Badu, 2019).

When the cocoons are collected, they are sorted and cooked to dissolve the Sericin which silkworm produce to cement the silk threads together while spinning. There are different methods of doing that, like the open and sunken systems. The open system includes open pan and three pan methods, whereas the sunken system includes pressure cooking and conveyer boiling. After cooking, reelers brush the cocoon and then the reeling of cocoon is done. After reeling, re-reeling is done to convert the yarn into bundles.

Types of silk reeling machines: There are various types of silk reeling tools used in silk reeling, from hand reeling it changed to machine reeling. These tools can be categorised as traditional and modern reeling machines. Traditional reeling tools include hand-operated charkhas, motorised charkhas, and country charkhas, while modern reeling machines include cottage basins, multi-end reeling machines, and automatic reeling machines. If we look back at the history of the reeling industry, we can see that it has undergone significant changes. In India, a sitting reeling machine is also used, which comes in two varieties: one that is pedal operated and the other that is motor driven. Sitting type machines include the country charka and cottage basin designs. The country charkha is a simple device that consists of a large cooking and reeling pan filled with boiling water (Figure 4). The cocoons are cooked, and the silk filaments, which have been brushed into a bunch, are threaded through a hole in a thread guide device. Then there were cottage basin reeling machines which were later upgraded to multi-ends and automatic reeling machine. In the 1960s and 1970s, cottage basin (CB) technology was introduced. These semi-mechanized production units were larger in scale than hand spindles, with spindles turned by a system of open belts and motors. They enabled the production of high-quality fine silk yarn that could be used directly on handlooms (Joseph, 2018). There is a hybrid machine also between the automatic and multi-ends reeling machines. It is called semi-automatic reeling machine (Ananthanarayanan, 2008). The images below were taken during the field work and shows the reeling machines used in Jammu and Kashmir to make thread out of cocoons.

Figure 4: Reeling done on country charkha by a reeler



Figure 5: Cottage basin reeling machine in a dilapidated silk filature established in 1917 at Solina, Srinagar, Jammu and Kashmir.



Figure 6: Multi-end reeling machine



Figure 7: Re-reeling machine



Figure 8: Semi-automatic reeling machine



Figure 9: Automatic reeling machine



Source: Author, Regional Sericulture Research Station, Miran Sahib, J&K

Each of these reeling tools is distinct in terms of capital investment, labour requirements, volume and quality of output, and energy consumption (Joseph, 2018).

1.6 Problems and Prospects: The Argument

The argument presented in this paper is based on a year of field work research on the silk industry of Jammu and Kashmir. There is not much secondary literature available on the Jammu and Kashmir silk industry and the state department websites are not currently maintained. So, in order to fully comprehend the scenario, I visited to the houses of silkworm rearers, the state regulated cocoon auction market, and the reeling units. To understand the line of development and the technological progress in the reeling sector of sericulture, I visited both the newly established and renovated government reeling units. I also went to the old non-operational reeling units established by the Dogra regime, which still exist in Kashmir. There are many private reeling units as well, which I visited. I also went to the Regional Sericultural Research Station, Bari-Brahamana and the State Sericulture Development Department of Jammu and Kashmir.

I conducted approximately eighty eight detailed semi-structured interviews and informal conversation with silkworm rearers, reelers, traders, weavers, and entrepreneurs. I also spoke with officials and the State Sericulture Development Department employees, Jammu and Kashmir Industries Ltd., and the Central Silk Board to understand the contesting realities. This includes both the face to face and telephonic interviews. The fieldwork is interpreted in the light of the theory to add validity to the research.

Jammu and Kashmir is a bivoltine silk-producing state and silkworms are reared twice in a year. The major crop is spring, which accounts for approximately 80 percent of the state's cocoon production, and the rest comes from autumn crops. Silkworm rearers can sell their cocoons only in the state sericulture development department-organized and regulated district auction centers. It is usually organized twice a year. The market for the spring crop is organized in March-April, whereas for the autumn crop, it is organized in October-November (S. Kumar, personal communication, May 8, 2020). There was a state monopoly until 1988, which meant that no private reeler could participate in cocoon transactions or silk reeling. Jammu and Kashmir industries Ltd. used to buy the entire cocoons for reeling. With the enactment of the Jammu and Kashmir Silk (Development and Conservation) Act 1988, open auction markets were established in Jammu and Kashmir and private reelers were permitted to bid for cocoons in the market. Before auction, the silkworm rearers sort their cocoons, which are graded A, B, C and D based on their quality. A floor price is fixed by the state department for various cocoon grades. However, the final price is determined by bidding at the auction market. Currently, the 'A' grade cocoon has a floor price of Rs 510; the 'B' grade has a price of Rs 135; and the 'C' and 'D' grades have prices of Rs 120 and Rs 18, respectively (A. Sharma, personal communication, August 28, 2020). These rates are revised from time to time. The participation of private reelers from the state and traders from other states, mainly Bengal, increase the competition and help the rearers get a reasonable price for their crop.

However, if the farmers do not get the price higher than the floor price, the state department is supposed to purchase the cocoon at the floor price. Depending on the yarn market, the cocoon price varies from season to season. The yarn price is determined by the existing demand for woven fabrics.

Jammu and Kashmir silk reeling sector scenario: In Jammu and Kashmir, the reeling was primarily done in two government silk filatures, Rambagh Silk Filature in Srinagar and Government Silk Filature in Jammu⁶. People used to spin silk on Charkha before reeling began in filatures. Reeling was only carried out in government factories when this industry was a state monopoly. However, with the de-monopolization in 1988, private reelers began to participate in the reeling process. The table below lists the private reeling units in Jammu and Kashmir.

Table 1.3: Reeling Units Functional/Non-Functional in Jammu Division

S.No.	Name of Reeling Unit	District	Type of Reeling Machine	Number of Basins	Established in the Year	Status
1	Sai Silk Industries	Bari-Brahamana, Jammu	Multi-End now Cottage	5	1994	Functional
2	Sheela Textiles Udyog	Umala, Udhampur	Cottage	8	1995	Functional
3	Meeras Touch	Umala Udhampur	Cottage	8	1996	Functional
4	Angels Silk	Umala Udhampur	Cottage	8	1997	Functional
5	Madhusudan Silks	Bari-Brahmana, Jammu	Cottage	6	1998	Functional
6	Vandana Enterprise	Udhampur	Multi-End	10	1995	Non-Functional
7	Premimum Silks	Lanci, Udhampur	Cottage	8	1997	Non-Functional
8	Shivalik Silks	Udhampur	Multi-End	6	1998	Non-Functional
9	National Silks	Udhampur	Multi-End	6	1999	Non-Functional
10	Ramnagar Silks	Ramnagar, Udhampur	Multi-end	10	2000	Non-Functional
11	Jeevan Textile Udyog	Udhampur	Cottage	8	2002	Non-Functional
12	Mahaluxmi Silk Industries	Ramkot, Kathua	Multi-end	10		Non-Functional
13	Royal Silks	Jammu	Cottage	6	2001	Non-

						Functional
14	Malika Silk Industries	Udhampur	Cottage	8	2001	Non-Functional
15	Sharma Silk Industries	Rajouri	Multi-end	10	2002	Non-Functional
16	Jai Balwalta Silk Works	Padanoo, Udhampur	Cottage	6	2002	Non-Functional
17	Global Handloom	Bilawar, Kathua	Cottage	6	-	Non-Functional
18	Karan Silk Industries	Nonial, Nowshera, Rajouri	Cottage	6	2009	Non-Functional
19	Aryan Silk Industries	Ramnagar, Udhampur	Cottage	6	2007	Non-Functional
20	Rashmi Silk Industry	Gajansoo, Jammu	Multi-end	10	2002	Non-Functional
21	Star Silk Industry	Gadigarh, Jammu	Multi-end	10	2003	Non-Functional

Table 1.4: Reeling Units Functional/Non-Functional in Kashmir Division

S. No.	Name	Districts	Type	Basins	Status
1	Himalayan Silks	Budgam	Cottage	6, 10	Functional
2	Kohinoor Silks	Srinagar	Multi-End	10	Functional
3	Raja Silks	Achabal	Multi-End	10	Functional
4	Bismillah Silks	Kanipora	Multi-End	10	Functional
5	Ab. Salam Dar	Pulwama	Multi-End	10	Functional
6	M/S Bombyx Mori	Srinagar	Multi-End	10	Functional
7	Kashmir Silks Emporia	Srinagar	Automatic Reeling Machine	200	Functional

8	Darson Cotton	Srinagar	Cottage	9	Functional
9	Emma Essko Group	Srinagar	Dying	10	Functional
10	Karson Silks	Srinagar	Multi-End	10	Functional
11	Bhat Silk Industry	Srinagar	Multi-End	10	Non-Functional
12	Malik Silks	Kulgam	Multi-End	10	Non-Functional
13	Jan Silks	Srinagar	Multi-End	6	Non-Functional
14	Imperial Silks	Srinagar	Multi-End	10	Non-Functional
15	Slikom Silks	Srinagar	Multi-End	6	Non-Functional
16	Crown Silks	Zakaura Industria l Estate	Multi-End	10	Non-Functional
17	Cash Wool Tex.	Srinagar	Multi-End	10	Non-Functional
18		Zakoora	Twisting	0	Non-Functional

Source: Directorate of Sericulture Development Department, Jammu and Kashmir.

Given that most private reeling units are non-functional and there is only few newly established public reeling unit, the state's potential to process the cocoon is very limited. Consequently, according to the Jammu and Kashmir Industries Ltd., only 30 percent of the cocoon is reeled within Jammu and Kashmir and 70 percent of the cocoon's harvest is sold to the outside reelers. The lack of a proper flourishing reeling sector makes the silkworm rearers dependent on outside traders and reelers, eventually, rendering them vulnerable to exploitation. While examining further, I subsequently discovered that the state also lacks a functioning raw silk exchange. Silk Exchange is a marketing system established for raw silk. It is a place where the silk yarn producers and the buyers can transact the raw silk. A nominal market fee is charged to each reeler and buyer for the marketing services. These markets have a floor price for the silk yarn per kg. It aids the reelers in fetching a fair price for the silk yarn and safeguards them from exploitation. However, conversations with the officials of

the state sericulture development department reveals that the silk exchange is not functional in the state anymore and the reason behind it is that it was running at a loss (A. Sharma and K. Singh, personal communication, August, 28, 2021). Private reelers have a grievance that the weaving sector of the state is not very robust. As a result, they do not get the potential buyers of the yarn easily and rely on outside traders, usually getting exploited and not earning a profit. Thus, one of the major problems the industry facing is the absence of the complete production chain. This absence further leads to no value addition in the waste produced during the different stages of the silk production.

Over the course of history, trade-oriented reforms have revealed that ideational shifts have been taking place at the technocratic level in the industry. As explicated in the earlier sections various silk reeling tools have been introduced gradually. A strong emphasis has been placed on the use of more productive technologies in the production of silk. Furthermore, there has been a political shift away from the employment and social welfare goals that had previously guided the policy. The Textile Policy 1985 and The New Textile Policy of 2000 both reinforced the shift in priorities, which focused on increasing competitiveness in global markets while paying little attention to job quality or quantity (Vijayabaskar, 2014). The state policy aimed at improving raw silk production focused more on expanding and technologically upgrading the existing state filatures. It also emphasised on installing imported, Automatic Reeling Machine (ARM) (Joseph, 2018). In Jammu and Kashmir, there is only one silk reeling unit with automatic reeling unit (A. Kumar, personal communication, January, 13, 2021). The impact of this modernistic idea of development of industry associated with more and more mechanisation and less dependence on the labour could be seen on both the silk worm rearers and the silk reelers. It contributed to the decline of the industry. Let us analyse how.

A close look at the rearing process reveals that it is the most challenging task, given that silkworms are very delicate. Even a minor mistake on the part of rearers or slight fluctuations in climatic conditions can ruin the crop. Nevertheless, the farmers do not get the price worth their hard work. Cocoon is a perishable item and the auction market is organized only twice in Jammu and Kashmir that often for a limited number of days. The silkworm rearers store cocoons for months before selling them in a state-regulated market, which requires a great deal of care and effort.⁷ They must keep it in good condition and protect it from reptiles and worms, which necessitate an expensive storage investment that the majority of them cannot afford it. There are no institutional storage provisions for the same. Consequently, the rearers have no choice but to sell their cocoons, even if they do not fetch a good price. If we look at the floor price, then the 'A' grade cocoon price is around Rs 510 per kg whereas the price of 'B', 'C' and 'D' grade costs only 135, 120, and 18 rupees per kg, respectively. Only the price of 'A' grade cocoons has increased over the years and in an official of the state sericulture development department explained in a personal

interview that the reason for this is to encourage the farmers to produce 'A' grade cocoon. The interesting fact to note here is that only high quality 'A' grade cocoon can be reeled in an automatic reeling machine. Motivating rearers to produce high-quality cocoon is a good idea, but many natural factors influence cocoon quality. The farmers are poor, not even have good rearing sheds and usually rear silkworms in their dwelling places. It is not justifiable not to increase the floor price of 'B', 'C' and 'D' grade cocoons. The state's emphasis on automatic reeling machine in the reeling sector exacerbates the situation for rearers. Even after all of their efforts, their living condition has not improved. One possible solution to this is to do add more value to their final products. If the rearers could do the first stage processing of the cocoon, they can get more money, comparatively. This would only be possible if the production were decentralised. For the decentralisation, it is imperative to introduce the appropriate technology that is both affordable and familiar.

Even with a state subsidy of 90%, the reelers are not switching to the ARM. To investigate the reasons behind it, I conducted interviews with private reelers in the state a focus group interview with 46 traders and reelers who came to the Jammu and Kashmir cocoon auction market. According to them, large mechanised and capital-intensive machinery is "neither affordable nor profitable". These are only available to those with capital to invest. They further explained the reasons why. First, in Jammu and Kashmir, there are only two crops of cocoon: spring and autumn. As a result, there are not enough cocoons to be reeled throughout the year. Second, the ARM can only reel the high quality 'A' grade cocoon. If they go for it, they won't be able to reel the 'B', 'C' and 'D' grade cocoon and more waste will be generated. Third, it is a less labour intensive unit but there is no dearth of labour in J&K. For these reasons, in context of Jammu and Kashmir, the country charkha and the cottage reeling machine are more profitable and efficient.

Looking at the big picture, one of the most serious issues confronting the Indian economy today is the degenerated rural economy. People are migrating to the urban areas in search of work. The on-going crisis of Covid-19 showed how grave this issue is. Today, the dire need of the Indian economy is to revive the rural economy and make it self-sufficient. One of the solutions to this problem is local industries (Sharma, 2021). The current socioeconomic realities, set against the backdrop of an economic slowdown and the Covid-19 pandemic, nudge us to expand our horizons of knowledge system, currently dominated by mechanization. There is need for cognitive justice, with the impetus on practice of plural knowledge systems.

As we know that Sustainable development is the key to futuristic model of growth. A possible solution to this broader problem, as well as specific problems in the silk reeling sector, could be the revival and revitalization of the traditional knowledge and the traditional technology. Traditional knowledge systems have enormous potential that should be realized to the optimum level.

The solution is to 'look at it the other way and not relegate it to scrap'. It can help to empower the communities at the grassroots and will decentralise the production process. There are various prospects of this idea. First, if production is decentralised, it will enable the rearers to do first stage processing of the cocoon and add value to their product. Second, the revitalised traditional technology will be more affordable and familiar to local people. As a result, the reelers with less capital to invest can also own it. Third, at the cultural level, if innovation is informed by the local knowledge, it will give a sense of dignity and empowerment to the local people who possess this knowledge. Fourth, it will be more efficient and profitable because it can reel all grades of cocoon. Last but not least, in view of the fact that this technology will be indigenously manufactured and will be easy to repair, it will reduce the dependence on the developed countries for technology transfer. For instance, the ARM is primarily imported from the China. India is already reliant on china for the import of wide range of goods and technology. According to the annual Chinese customs data, India's trade deficit with China crossed \$100 billion mark for the in 2022, while overall trade touched an all-time high at \$135.98 billion, recording a surge of 8.4% as compared with the previous year. Having locally manufactured technology will increase the efficiency and autonomy of the India's silk industry.

What I am arguing here is not to demonize the modern technology, but to incorporate the traditional one also for the better and more inclusive development. The revival and revitalisation of traditional silk reeling technology and its syncretism with modern technology will lead to more equitable and sustainable development. If the innovation is informed by the sustainable knowledge, which is a blend of scientific, professional and local knowledge, it has the potential to lead to a locally appropriate sustained growth of Jammu and Kashmir's silk industry. I refer this process as epistemic syncretism, where there is plurality of knowledge and all knowledge systems are given their due cognitive validity. This idea also resonates with the Schumacher's idea of appropriate technology as it will lead to innovation of small-scale, affordable, decentralized, labor-intensive, energy-efficient, environmentally sustainable, and locally autonomous technology (Schumacher, 2011). This technology will be people centric. The traditional ways and tools of silk reeling show pathways for the sustained production and inclusive development. It has the potential to improve the prospects for the growth of healthy silk producing community.

1.6.1 Lessons from the Edge:

To corroborate the argument presented in the paper, I will discuss the two stories discussed by Stephen Hill in his paper arguing about the potential of traditional technologies towards environmental conservation and sustainable development in this section. He described how traditional technological lessons can be exported further up the global chain. The first story depicts a traditional

society confronted with modern globalisation technologies. To improve fishing yields, 2000 inboard motor crafts were introduced in a Sri Lankan fishing village between the 1960s and the mid-1970s. It was a programme introduced by a foreign expert who had no knowledge of the local context and whose fishing experience was primarily with large industrial enterprises. The boats were quite expensive. Therefore, to promote their use subsidies were introduced. The villagers abruptly transitioned from the traditional production system to a modern cash economy. The villagers had no knowledge of these new Norwegian boats with Japanese engines. As a result, when the boats broke down, they were unable to repair it. The boats lay idle as the villagers also could not afford the repairing cost, preventing them from repaying their loans. The wealthier boat owners bought these second hand boats as they had resources. This increased their wealth and strengthened their elite position. Paul Alexander observed that the yield of fishing increased by 7 to 8 times in 15 years while the total number of fishers employed decreased by 50% (Alexander, 1977 in Hill, 1995). It benefited only those who had purchasing power to access it (Hill, 1995).

The review of the literature highlighted that in recent years, there has been a surge of interest in indigenous knowledge and its potential to solve both local and global crises. However, these knowledge systems are rapidly disappearing in most parts of the world. Hill argues that for environmental protection and sustainable development, there is a need to identify and promote the appropriate technologies. The link between the local and global production systems needs to be addressed. This necessitates rewriting and establishing local knowledge and technology texts at each stage along the path. Local technology and knowledge must be empowered in order to ensure they articulate with the globalized system. An example of this exercise, which is the second story, is the redesigning of the spinning machines in the Uttar Pradesh region of India to fit the semi-automatic weaving machines. This example demonstrates how epistemic syncretism can transform the relationship between modern and traditional technologies into strength rather than weakness. To use spun cotton threads in traditional villages, automatic weaving looms were introduced in Uttar Pradesh, a state in northern India. Unfortunately, the peasant's threads could not be used as it clogged up in the machines which required standard inputs. The situation had profound impact on the traditional cotton thread producers the factory owners were forced to use synthetic thread. It made cotton to vanish from the market. The new modern technology pushed peasants off the global culture's market shelves, preventing the benefits from trickling down to them. Fortunately, in this case, the Garge, the old engineer in Lucknow, contemporary of Schumacher, recognised the issue and made only minor changes to the spindles that formed a node when the thread was spun. He realised that if he replaced traditional spinning tools with new ones to meet the power loom requirement, the machine would have to be able to be manufactured and repaired locally, or it would have social design

consequences. In this case, a small innovation with change in the traditional technology led to the development of a better technology that is more efficient (Schumacher, 2011 in Hill, 2006).

1.7 Conclusion

With the lessons in mind we can revisit the conclusions suggested earlier. The present development model is sinking and an alternative is required. The indigenous knowledge systems and the traditional technology could be that alternative. A balanced syncretism of modern and the traditional technology will result in a more locally appropriate sustainable development. To meet the influx of demand, technological progress has happened throughout history. Even after the introduction of large mechanised and apparently more efficient reeling machines, the silk sector in Jammu and Kashmir is declining. An examination of the matter through field work revealed that the traditional reeling methods are more appropriate and profitable for the Jammu and Kashmir's silk reeling sector. I propose that 'epistemic syncretism' in this sector will show pathways to more inclusive, sustained and equitable growth of the industry. It will also result in cognitive justice and social justice.

References

- Alexander, P. (1977). Australian Broadcasting Commission, Transcripts on the political economy of development. Sydney: ABC.
- Badu, K. M. (2019). Silk reeling and silk fabric manufacture. Woodhead Publishing: Cambridge, UK.
- Banerjee, M. (2021). The Politics of Knowledge in Development: An Analytical Frame. *Studies in Indian Politics* 9(1), 78-90, <https://doi.org/10.1177/2321023021999176>
- Bardhan, B. (2018). Reflections on kalyan sanyal's rethinking capitalist development. *Economic and Political Weekly*, 53(21), 19-22.
- Berkes, F., & Jolly, D. (2002). Adapting to climate change: social-ecological resilience in a Canadian western Arctic community. *Conservation ecology*, 5(2).
- Berkes, F., & Jolly, D. (2002). Adapting to Climate Change: Social-Ecological Resilience in a Canadian Western Arctic Community. *Conservation Ecology*, 5(2). <http://www.jstor.org/stable/26271828>
- Brouwers, J.H.A.M. (1993) Rural people's response to soil fertility decline: The Adja case (Benin), Wageningen Agricultural University Papers, 93-4.
- Brundtland Commission (1987). Report of the World Commission on Environment and Development: Our Common Future. Oxford University Press.
- Claxton, M. (2010). Indigenous knowledge and sustainable development. UWI.
- Cornwall, A., and Deborah Eade (2010). Deconstructing development discourse: Buzzwords and fuzzwords. Oxfam.
- Deb, D. (2009). Beyond Developmentality: constructing inclusive freedom and sustainability. Earthscan.
- Demaria, F., and Ashish Kothari. (2017). "The Post-Development Dictionary agenda: paths to the pluriverse." *Third World Quarterly*, 38(12), 2588-2599.
- Dewangan, S. K. (2017). Sericulture for Sustainable Development, Employment Generation And Socio-Economic Empowerment Of Tribal. *International Journal of Current Research*, 9(11), 60280- 60288.
- Escobar, A. (1995). Encountering Development. Princeton University Press.
- Eyong, C. T. (2007). Indigenous knowledge and sustainable development in Africa: Case study on Central Africa. *Tribes and tribals*, 1, 121-139.
- Fennell, S., Holmes, J., & Jones, B. (2018). Smart cities need smart villages. *Economic and Political Weekly*, 53(12), 15-18.
- Fernandez, M.E. (1994) Gender and indigenous knowledge. *Indigenous Knowledge & Development Monitor* 2, 6-7.
- Gandhi, M.K. (2010). Hind Swaraj. Prabhat Prakashan.
- Ganga, G, & Chetty, J.S. (1997). An Introduction to Sericulture. New Delhi: Oxford & IBH Publishing.
- Gumbo, M. (2014). Indigenous Technology. In: Gunstone, R. (eds) *Encyclopedia of Science Education*. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-6165-0_367-2

- Gupta, A. D. (2011). Does indigenous knowledge have anything to deal with sustainable development? In *Antrocom: Journal of Anthropology*, 7, 59-64.
- Harriss-White, B., & Heyer, J. (Eds.). (2014). *Indian capitalism in development*. Routledge.
- Hill, S. (1996) *Technology Policy, Environmental Conservation and Sustainable Development in the Asia-Pacific Region. Traditional Technology for Environmental Conservation and Sustainable Development in the Asian-Pacific Region*, 6-19.
- International Sericulture Commission. (2013). *Sustainable Development Goals*. ISC, <https://inserco.org/en/millennium>
- Joseph, N. (2018). *The socio-politics of producing silk and accumulating gold in a South Indian town through the liberalisation reform period* (Doctoral dissertation, Paris Sciences et Lettres (ComUE)).
- Kasi, E. (2013). *Role of Women in Sericulture and Community Development: A Study from a South Indian Village*. SAGE Open 3(3).
- Kothari, A. (2014). Radical ecological democracy: a path forward for India and beyond. *Development*, 57(1), 36-45.
- Kothari, A., & Joy, K. J. (Eds.). (2017). *Alternative Futures: India Unshackled*. New Delhi: Authors Upfront.
- Kothari, A., Demaria, F., & Acosta, A. (2014). Buen Vivir, degrowth and ecological Swaraj: Alternatives to sustainable development and the green economy. *Development*, 57(3), 362-375.
- Kothari, A., Salleh, A., Escobar, A., Demaria, F., & Acosta, A. (2019). *Pluriverse: A Post- Development Dictionary*. New Delhi: Tulika Books.
- Magni, G. (2017). Indigenous knowledge and implications for the sustainable development agenda. *European Journal of Education*, 52(4), 437-447.
- Ministry of Rural Development, Government of India (2019). *Wasteland Atlas-2019*. Press Information Bureau. <https://pib.gov.in/PressReleaseDetailm.aspx>
- Ministry of Textiles, Government of India. (2018). *Central Silk Board*. <https://csb.gov.in/>
- Narsaiah, M. L. (1999). *Development of sericulture*. New Delhi: Discovery Publishing House.
- Nugroho, K., Carden, F., & Antlov, H. (2018). Local knowledge matters (p. 192). Policy Press.
- Okhandiar, R. R. (2019). *Seri-States of India 2019-A profile*. New Delhi: Astral international.
- Rahaman, A.H., 2009. *Impact Of Globalization Of Trade On Development Of Sericulture In Murshidabad District West Bengal*.
- Rani, G.S. (2011). *Sericulture and Rural Development*. Discovery Publishing.
- Riello, G., & Roy, T. (2009). *How India clothed the world: the world of South Asian textiles, 1500- 1850*. Brill.
- Rist, G. (2003). *The History of Development: From Western Origins to Global Faith*. Expanded Edition. London: Zed Books.
- Rist, G. (2008). *The history of development: From western origins to global faith* (P. Camiller, Trans.). Zed Books.
- Roy, C., Mukherjee, S., & Ghosh, S. (2012). *Sericulture as an Employment Generating Household Industry in West Bengal (A Study on its Current*

- Problems & Prospects). MPRA, Paper no. 43672, <https://mpra.ub.uni-muenchen.de/43672/>
- Sachs, W. (Ed.). (1997). Development dictionary: A guide to knowledge as power. Orient Blackswan.
- Sanyal, K. (2014). Rethinking capitalist development: Primitive accumulation, governmentality and post-colonial capitalism. Routledge.
- Schumacher, E. F. (2011). Small is beautiful: A study of economics as if people mattered. Random House.
- Scoones, I. (2009). Livelihoods perspectives and rural development. *The Journal of Peasant Studies*, 36(1), 171-196.
- Sen, A. (1988). The concept of development. In H. Chenery & T.N. Srinivasan (Eds.), *Handbook of development economics* (pp. 9-26). Elsevier Science Publishers.
- Sharma, P. (2021, February 2). Sericulture and Rural development in Jammu and Kashmir. *Jammu Kashmir Latest News | Tourism | Breaking News J&K*. <https://www.dailyexcelsior.com/sericulture-and-rural-development-in-jammu-and-kashmir/>
- Vijayabaskar, M. (2015). Emerging Spatio-technical Regimes of Accumulation in the Globalising South and Implications for Labour. *Indian capitalism in development*, 136-152.
- Tharakan, J. (2017). Indigenous knowledge systems for appropriate technology development. *Indigenous People*, 123-134.

List of Tables

Table 1.1: Stages in the Silk Production Chain

Table 1.2: Table given below shows the time it takes to form cocoon.

Table 1.3: Reeling Units Functional/Non-Functional in Jammu Division

Table 1.4: Reeling Units Functional/Non-Functional in Kashmir Division

List of Figures

Figure 10: Un-hatched Silk Worm Eggs.

Figure 11: The pictures given below are taken during the different instar and moulting periods.

Figure 12: Following pictures taken during field study shows the mountages used and the spinning process.

Figure 13: Reeling done on country charkha by a reeler

Figure 14: Cottage basin reeling machine in a dilapidated silk filature established in 1917 at Solina, Srinagar, Jammu and Kashmir.

Figure 15: Multi-end reeling machine Figure 16: Re-reeling machine

Figure 17: Semi-automatic reeling machine

Figure 18: Automatic reeling machine

Notes

¹ In this paper the term indigenous knowledge systems (IKS), 'already existing knowledge systems (AEKS),' 'traditional knowledge,' 'local knowledge,' 'folk knowledge,' 'people's knowledge,' and 'traditional wisdom,' is used synonymously.

² The period between egg hatching and spinning of cocoon is called larvae stage.

³ Instar is feeding period when silkworm eat the leaves

⁴ Moults is the non- feeding period of silkworm when it sleeps after feeding.

⁵ Cocoon sorting is a process of separating defective cocoons from good cocoons. The process also includes segregating cocoons according to their size. The purpose of stifling is to kill the pupa inside the cocoon to avoid its emergence as a moth. The cocoon is also dried to kill pupa inside so they can be stored for a long period.

⁶ This filature was closed in 2002 and demolished in 2011 to build a multi-speciality hospital.

⁷ In Jammu and Kashmir (J&K), the cocoon can be sold only in a state regulated auction market. To transact cocoon outside the auction market is illegal in J&K.

Innovation in the informal sector: towards inclusion in alternative development pathways

Ii-haam Petersen, Glenda Kruss

Human Sciences Research Council, South Africa

Abstract

Informal enterprises play a critical role in economic survival in South Africa, and other countries in the global South. The main contribution of this paper is an empirically grounded understanding of modes of innovation and the associated capabilities in informal enterprises. The paper draws on mixed methods participatory research in two resource-poor settings in South Africa to explore the kinds of innovation capabilities that exist within informal food service micro-enterprises. Using a local innovation and production systems (LIPS) approach, the paper maps patterns of innovation and analyses the kinds of knowledge and technology resources informal enterprises draw on, their forms of learning and how these are shaped by local practices and institutions. The paper demonstrates that informal enterprises with necessity driven innovation capabilities require different kinds of support than those with diverse pathways towards opportunity driven innovation capabilities. It identifies the ways in which building the innovation capabilities of informal enterprises could contribute to local level diversification and potentially, to structural transformation, over time.

1. Introduction

Democratic South Africa is widely recognised as one of the most unequal countries globally, reflected in the highest GINI coefficient in the world, accompanied by shockingly high unemployment figures, particularly amongst young people. The country has been unable to break out of a middle income trap for more than 70 years, and currently, there are dynamics that might signal a decline to a lower development status (Kruss 2021). All of these conditions are exacerbated by the decimating impact of the global COVID pandemic.

South Africa has no shortage of developmental visions, policies and strategies, including a focus on inclusion of those most marginalised to address poverty and unemployment (identified as African women, youth and the disabled); on local economic development; and on promotion of SMMEs. Yet the gap between the aspiration and the reality of implementation gets wider every year, as does the inequality gap. These challenges stimulate much economic and political analysis attempting to find ways to break the impasse.

One dimension that has been relatively neglected, but is now increasingly receiving attention, is the fact that millions of people do find a way to earn some kind of income that enables them to survive. Research suggests that while the informal sector in South Africa is smaller than in other African and developing countries, it is growing rapidly in size and significance (Charman and Petersen, 2018; Charmes, 2016; Fourie, 2018a; Kroll et al, 2021). Estimates are that the informal sector accounted for 6% of GDP in 2017, and that 18,3% of the employed work in the informal sector, and 30% in informal employment in the formal sector, as at Q3 of 2019 (Statistics South Africa, 2020).

These are the multitudes of informal micro-enterprises located in townships, peri-urban and rural areas, many providing basic goods and services that are affordable to the resource-poor communities and households who live at a spatial distance from the urban and metropolitan centres of the formal economy¹.

The national priority focus is on finding alternative pathways for structural transformation of the economy. Economists argue for the need to shift away from premature deindustrialisation, and to break the historically high levels of concentration of economic power in a small number of large firms that entrench barriers to entry for more, smaller firms (Andreoni et al, 2021). The solution is widely seen to lie in change through investment in building productive capabilities, enabling technologies and learning, across a wide range of sectors, global and local value chains, organisations and institutions.

A fresh approach requires growth enhancing structural change matched by public and private investment in productivity enhancing sectors coupled to the development of the necessary skills and technological knowledge (Moleko and Swilling, 2021: 4).

Where the informal sector is included in national policy, the thrust often tends to be on strategies aimed at formalisation and regulation of their business activities (Institute for Economic Justice, 2018; Statistics South Africa, 2020; Jutting and de Laiglesia, 2009).

Nevertheless, there are compelling suggestions to explore the ‘transformative potential’ (Charman et al, 2020) of informal micro-enterprises (Fourie, 2018b; Valodia and Devey, 2010). A research and policy focus on growing ‘township’ and informal local economies is emerging, typically as part of provincial or city-level local development strategies, and often rooted in the non-governmental organisation sector (Charman et al, 2020; Gauteng Province, 2014; Kroll et al, 2021; Razafindrakoto, 2009; Fourie, 2018a; Kraemer-Mbula and Wunsch-Vincent, 2018; De Beer et al, 2013; Kraemer-Mbula et al, 2019; Rogan and Skinner, 2018; Du Toit and Neves, 2006; Neves et al 2011; Petersen et al, 2019). While here too, the dynamics of concentration and extraction to the benefit of large companies may tend to constrain what is possible, there is strong evidence that informal enterprises grow because they provide “services that are culturally acceptable within communities” (Charman et al, 2020: 295). Herein lies one reason to explore the dynamics around their potential role.

An inter-linked reason to focus on the informal sector lies in the potential contribution to a fresh approach, anchored in local economic development plans. Countries stuck in a middle income trap are typically encouraged to focus interventions on areas where they have an advantage (such as commodities), and areas that are showing potential to build niches, as a way to build manufacturing capabilities. The demand-driven nature of the informal sector holds promise for locally-derived novel solutions that could be scaled, and for building niche areas that better address local demand. A focus on the local level also addresses the need for more spatially targeted policy interventions to address inequality within and between regions within the country (Tregenna, 2015, 2016; Andreoni et al, 2021).

Building forward and backward linkages across value chains to include informal enterprises at the local level can be a way to pave pathways for more inclusive industrial diversification (Morris and Fessehaie, 2014). Promoting linkages across value chains supports learning – through formal skills development and research and development as well as experiential learning – and capability building, that can contribute to cumulative or collective capabilities in a region. Building a wider range of collective capabilities at the local level enables more novel forms of innovation, which allows for higher levels of economic diversification in the system as a whole, in more inclusive ways.

The challenge, however, is to identify ways to build the types of innovation capabilities that have transformative potential. Although the issues are complex, there are significant, large literatures available to understand the

innovation capabilities of firms, universities or public research institutes and other intermediary actors. In contrast, there is very little published research available on informal enterprises. We do not have much research or evidence on informal enterprises' capabilities for learning and innovation, in order to link into local value chains. This makes it difficult to assess whether and how their mix of knowledge and the institutions in which they are embedded can support innovation activities with transformative potential.

To address this gap, the paper proposes a focus on assessing informal enterprises' knowledge bases for building collective capabilities, and how these shape and affect innovation activities in their resource poor local contexts. This points to new exploratory research questions: What are the kinds of innovation capabilities that exist within informal micro-enterprises, what are the kinds of knowledge and technology resources they draw on, what forms of learning are taking place, and how are they shaped by local practices and institutions? How do these types of innovation capabilities enable integration into local value chains in transformative ways?

These questions are used to focus the conceptual and empirical analysis. The main objective is to explore the capabilities and knowledge structures reflected in the actual forms and patterns of innovation that take place in typical informal enterprises, situated in spatially distant and resource poor areas.

The paper proceeds by setting out a conceptual and analytical approach to investigate innovation capabilities in informal enterprises in South Africa, in Section 2. Section 3 describes the methodology and datasets of two mixed methods studies that provide the empirical data for analysis, focused on informal food enterprises. Section 4 analyses the patterns of innovation and learning in informal food micro-enterprises embedded in a food local innovation and production system, drawing on survey data. Section 5 builds on this descriptive analysis using in-depth case study data, to develop a distinction between types of innovation capabilities that can be linked to alternate development pathways.

2. Local innovation and production systems approach

The analytical approach is based in the innovation systems literature, specifically, in the literature on innovation and inclusive development in the global South (Cozzens and Sutz, 2014). The framework of Local Innovation and Production Systems (LIPS) (Cassiolato and Lastres, 2020) was identified as particularly useful for assessing the potential role of informal micro-enterprises. The analysis is complemented by key concepts from a neo-institutionalist literature that enable more fine-grained analysis of the practices and belief and value systems within local systems and informal enterprises that shape capabilities for innovation and learning.

The LIPS model was pioneered in Brazil by innovation researchers facing similar development challenges to South Africa, given their colonial histories (Cassiolato and Lastres, 2020; Cassiolato et al, 2017; 2018; Lastres and Cassiolato, 2018). A LIPS is defined as

“...(a) group(s) of economic, political and social agents localised in the same area, performing related economic activities, in which formal and informal interdependence and consistent linkages usually result in cooperation and learning processes, with a potential to generate the increase of productive and innovative capabilities” (Lastres and Cassiolato, 2005:7).

The set of agents at the collective level is the unit of analysis, rather than individual businesses, sectors or production value chains, and emphasis is on understanding the close relationship between the spatial territory and economic activities (Cassiolato et al, 2017).

2.1. Main actors, networks, and their production activities

The starting point is to map the key actors, flows of resources and knowledge in a LIPS in a specific sub-sector and spatial terrain. Typically, when value chains are mapped, they leave out informal actors, whether enterprises, customers or finance and knowledge providers. A small but growing body of South African research suggests that the formal and informal sectors are not dichotomous, but should be understood as interacting, and on a continuum of economic activity (Valodia and Devey, 2010). The LIPS model recognises such an approach, by emphasising the significance of fundamental linkages and inter-connections within spatial territories, and that the formal and informal sectors are not located in distinct economies or separate systems. By blurring these boundaries, the LIPS model makes it possible to investigate how formal and informal actors are integrated - or not - in local systems.

Distinct but related roles are played by informal and formal actors, in multiple segments of value chains and innovation processes. The analytical focus therefore falls on an integrated and mutually inter-dependent set of actors and activities, knowledge flows and flows of goods and services, within a spatially defined geographical area. Mapping these can highlight where capabilities and learning are strong or weak or can be developed in the local system. Cumulative capabilities at the local level can contribute to regional and national development.

At the centre of the LIPS for our analysis is the ‘informal production unit’. Informal sector enterprises are defined as those that are unregulated but engaged in legitimate economic activity, in a manner aligned with the standard ILO definition². In terms of size, the South African National Small Business Act (No 26 of 2003) defines a micro-enterprise as employing fewer than five people, with an annual turnover less than R200 000 and assets less than R100 000. Considering the nature of the informal sector in South Africa, few informal

micro-enterprises employ more than one or two people and the majority tend to be single owner enterprises (Fourie, 2018).

2.2. Socio-economic characteristics of the local territory

In South Africa, informal enterprises are typically located in residential areas that are poorly resourced, in townships, peri-urban and peri-rural areas, that are spatially distant from retail or industrial hubs. This means that the enterprises are often located in areas displaying high levels of unemployment and poverty. These enterprises are important sources of affordable goods and services for low-income and impoverished households. For example, it is estimated that 70% of township households rely on informal traders for food (Crush and Frayne, 2011). A major challenge is access to basic services such as potable water and flushing toilets, which is often an area of contention between residents and local government. Since poverty and inequalities in South Africa are closely related to race, the majority of the population living in resource-poor areas tend to be black African and most tend to have low levels of formal schooling and training.

It is important to consider how these socio-economic conditions shape production and innovation activities.

2.3. Forms of knowledge and capabilities for innovation in informal enterprises

The LIPS enables an understanding of the structure, roles and opportunities, but does not provide fine-grained insights into the innovation capabilities that shape the transformative potential of informal enterprises. Concepts are required that allow for analysis at the micro-level, of the nature and "success" of an informal enterprise, its modes of innovation, forms of knowledge valued and its capabilities for learning and growth.

Nubler (2014) proposes a "knowledge-based concept of collective capabilities", distinguishing between three types of capabilities, based on conceptual knowledge, procedural knowledge and beliefs and value systems. Conceptual knowledge or 'knowing that', is rooted in knowledge structures and evident in general principles, rules and ideas – these can be acquired through education and training. Procedural knowledge or 'knowing how' is rooted in the routines and institutions that prevail or change in the work/production space. Belief systems relate to shared mental models and mindsets that shape innovation behaviour.

Based on our empirical research, we find it necessary to further distinguish types of knowledge that make up conceptual and procedural knowledge, and the institutions guiding behaviour, considering the high degree of local embeddedness of informal production and innovation activities.

Firstly, similar to Nubler, we distinguish between competences and capabilities. Competences relate to 'knowledge' held at the individual or organisational level, and stem from the pre-set attributes that are typically produced by education and training organisations (Von Tunzelmann and Wang, 2003; Von Tunzelmann et al, 2010; Kraemer-Mbula et al 2019). Competences include cognitive aspects such as beliefs and attitudes that influence learning. We make a further distinction: competences based on knowledge embedded in people and knowledge at the collective level, embedded in institutions (Petersen et al, 2022). Capabilities in contrast, relate to the use and application of competences in specific settings, to bring about a desired change. For example, an informal trader may attend a formal business course and acquire new competences, but this does not guarantee that she will be able to grow her business by applying the new principles learned. To do so requires agency and "institutional work", the "purposive action" taken to actively maintain, disrupt and change norms, values and practices in her business (Lawrence and Suddaby, 2006: 215).

2.4. Knowledge at the individual/enterprise level

Lundvall (2016: 112) disaggregates procedural and conceptual knowledge even further: which can be summarised as procedural forms of 'know-how' and 'know-who' (when and where), and conceptual forms of 'know-what' (facts) and 'know-why' ('specialised scientific knowledge'). For example, over time, from their own experience and activity, informal traders may have learned the 'know how' and 'know-what' of the needs and preferences of the local consumer market. 'Know-how' can be developed through learning on the job, as well as through courses and incubation programmes. 'Know-who' and 'know-how' are mainly tacit forms of knowledge and not easily accessible, except through interaction and collective learning (Lundvall, 2016). 'Know-who' relates to the ability to identify and form relations with others who have relevant knowledge, capabilities and resources (Lundvall, 2016: 112). 'Know-who' relates to social capital and the 'social ability to cooperate and communicate with different kinds of people and experts', which is important for building innovation and production relationships within a LIPS (Lundvall, 2016: 137).

A feature that is not covered by Lundvall's (2016) knowledge categories but is of value to the sustainability and growth of informal micro-enterprises in African countries, is the importance of traditional and local knowledge. The sustainability of informal enterprises in longstanding sectors such as food and textiles is to a great extent attributed to the use of "symbolic knowledge", that is knowledge based on "the cultural meaning of ideas, images and design", and that has "a high degree of place specificity" (Asheim et al, 2011: 882). Informal enterprises typically possess intimate

knowledge of the local market, which relates to their 'know-who' forms of knowledge, but also 'know-how' and 'know-why' that is rooted in traditional

knowledge. “Symbolic knowledge” (Asheim et al, 2011: 882) and ‘know-who’ become more useful when combined with relevant ‘know-how’, which is usually developed through work experience in a relevant industry, and scientific knowledge centred on facts (‘know-what’) and ‘know-why’ (see also Petersen and Kruss 2021).

Clearly then, an informal enterprise does not rely on or use only one type of knowledge at a time but will use different combinations as it responds to new opportunities or shocks³ in the local space. The ability to learn through ever more diverse and complex knowledge modes will determine the level of novelty of an innovation. In turn, ‘inter-firm diversity of innovation’ in a sub-sector (Marsili and Salter 2005: 87, drawing on Dosi 1988 and Nelson and Winter 1982) or local system will drive new pathways for evolution within an industry or local economy.

Therefore, an important goal for building a LIPS is to improve the diversity of innovation capabilities within the system, towards shifting innovation to higher degrees of sophistication. Rather than relying mainly on innovation focused on very minor adaptations to existing products or processes, innovation could involve a degree of creative imitation, leading to incremental changes to existing products or processes, or advanced modifications leading to differentiated versions of new products or processes (Bell and Figueiredo 2012: 21).

Analysing how informal enterprises use combinations of these types of knowledge and modes of learning provides understanding of their capabilities to innovate, in order to shift to pathways that allow growth, whether in their ability to employ others, to create greater profit or to become more sustainable.

2.5. Institutions, knowledge at the collective level

Charman et al (2020) note that informal enterprises typically have strong linkages to local institutions, to the norms, values and cultural practices of the township or peri-rural location that historically segregated and shaped the lives of those who are African. Informality is part of the social and economic culture. For example, in township economies, the lines between residential and business boundaries are blurred, despite the efforts of government to separate the two through creating designated, regulated trading areas. Locals prefer to locate their businesses near their customers or to save money by operating from their homes or sleeping at their businesses. A house is not just a place to sleep, but can also be a business, a place to welcome people/clients/customers and a source of income (Petersen and Magawana, 2020). How do such rules, norms and beliefs influence the kinds of knowledge typically shared and learning strategies that shape innovation capabilities? For example, a lack of trust or culture of learning through interaction may hinder collective learning, which is crucial for innovation in informal enterprises (Petersen and Kruss, 2021).

The innovation studies literature tends to be limited in tools for understanding how norms, values, and beliefs shape innovation capabilities. A common distinction is between 'formal' institutions including physical entities (e.g., schools and universities) and behaviours that can be recorded and emulated by others (e.g., patents, contracts, laws. etc.); and 'informal' institutions, which are more tacit and are thus not easily shared and emulated (e.g., attitudes, routines and habits) (Fagerberg and Srholec, 2010; Lundvall et al, 2009; Schoser, 1999). Nubler's (2014) knowledge-based capabilities framework is more useful as it goes beyond broad understandings and binary distinctions such as tacit/codified and informal/formal to identify different categories of institutions, norms, regulations, and belief systems.

Such an understanding is well-established in the neo-institutionalist literature (Fligstein and MacAdam, 2012; Garud et al, 2017; Lawrence, 2008; Lawrence and Suddaby, 2003; Leca et al, 2008; Scott, 1995). Here institutions are defined as "taken-for-granted, culturally embedded understandings" (Garud et al., 2007: 958), that provide meaning and rules that are collectively valued as guides for acceptable practice and are evident in habits and routines. Three pillars of institutions are identified: regulative, which relates to rule-setting, and monitoring and sanctioning behaviour through formal or informal regulatory mechanisms; normative, relating to what is valued and considered to be acceptable; and cognitive, which focuses on cognitive frames, beliefs and assumptions (Scott, 1995).

These 'culturally embedded understandings' are deep-rooted but not static. Institutions are actively negotiated and maintained by people who consider them legitimate and can be disrupted and changed through "purposive action" or "institutional work" (Lawrence and Suddaby 2006: 215). A neo-institutionalist understanding of institutions thus provides a useful understanding not only of the important role of practices, norms, and values in shaping capabilities, but of how these can be disrupted and changed. This is important considering that institutions contribute to path dependencies that may serve to constrain or enable agency.

2.6. Capabilities for learning and innovation in informal enterprises

A distinction is typically drawn in the SME literature, between enterprises that are 'necessity' driven and those that are 'opportunity' driven (BER, 2016). Necessity driven enterprises are essentially survivalist enterprises that may keep going over time but lack the capabilities to grow. They are likely to have weak knowledge flows and flows of goods and services within the local innovation and production systems, and weak capabilities to take advantage of opportunities in the LIPS (Petersen and Kruss, 2021). Those that are opportunity driven may have stronger capabilities to find opportunities to grow in size, or degree of formality, or access to supplier or customer value chains and networks, whether formal or informal. Hartnack and Liedeman (2017) however,

warn against viewing this distinction as a binary divide, and again, propose more complex types found along a continuum (cf. Mbaye and Gueye, 2020).

The challenge is to grow capabilities for diversification and the adoption of more opportunity driven strategies through innovation, including the use of digital technologies, by more informal enterprises, to reinforce potential virtuous circles and link them to local, regional and national development pathways.

Drawing on this distinction in entrepreneurship models and our empirical research on innovation in informal enterprises (Petersen and Kruss, 2021), two main sets of innovation strategies can be extracted that provide insight into how specific forms of knowledge and learning, shaped by locally embedded institutions, lead to specific types of innovation capabilities and activities:

1. A survivalist innovation strategy, whereby enterprises make minor adaptations to existing offerings that help them to survive.
2. An opportunity-driven strategy, whereby enterprises use local knowledge in ways that create potential for entering niche markets, by linking more strongly into the local innovation and production system, including formal value chains.

Necessity- and opportunity-driven enterprise innovation strategies are not binary opposites but represent the business evolution pathways reflecting different degrees complexity in the innovation capabilities of informal enterprises. Nor can such evolution be a linear process, as informal enterprises navigate along multiple growth trajectories that may take them forwards and backwards over time (CeSTII 2020b).

2.7. Impact of institutions and dynamics at the regional, national international levels

The LIPS model was adopted as best offering a multi-level perspective to situate and understand capabilities at the local level, but at the same time, how they relate to regional, national and global dynamics. The informal sector allows for the circulation of value within a local area, and hence to the benefit of strengthening a LIPS, rather than deepening economic concentration through extraction of profit by the large corporations and financial organisations that dominate the South African economy. For example, when a family buys food from an informal trader in their neighbourhood as opposed to a large supermarket in the local mall, the average rand spent can circulate a number of times in the local economy, when that trader spends their daily profit on their own needs, potentially creating opportunities for wider economic participation and virtuous circles (Alcock, 2018). Through an analysis of the provincial, national and international contexts, it is possible to gain insight into external constraints and facilitators of local production and innovation, and how these factors shape path dependency.

The LIPS framework thus allows for deeper understanding of the potential for informal enterprises to play a role that enables technological capability building, structural change and growth.

3. Drawing on two mixed methods research studies

The paper draws on qualitative and quantitative data created through two mixed methods research studies. Both studies used novel in-depth participatory research methods, such as digital storytelling, as a means to understand the perspectives, values and experiences of informal business owners.

These were complemented by semi-structured interviews with informal business owners and other key actors in the specific local innovation and production system.

3.1. An in-depth study of informal food traders using participatory methods

The first study was based in a Cape Town township and focused on informal food traders centred around a township innovation hub (Petersen and Magawana, 2020; Petersen and Kruss, 2021).

The township dates back to the 1800s when, under British rule, the area was designated for agriculture and the development of a mission station (Haysom et al, 2017: 1). The township emerged in response to apartheid racialised spatial planning that led to a housing crisis, and a rapid increase in informal settlements on the outskirts of the city. Township areas established during the apartheid era were designed as primarily residential areas for workers reliant on employment elsewhere (Charman et al, 2012: 4). In the early 2000s, local government developed transport links so that the area became a major regional node for bus transport to and from a largely rural neighbouring province, the Eastern Cape, where 'homelands' were created under apartheid (see Du Toit and Neves 2006). Migration from the rural areas resulted in a very densely populated township: in comparison to the rest of Cape Town (1 530 persons/km²), the area is densely populated (4 182 persons/km²) and the population is growing at a fast pace. Metropolitan government has identified the area for major development in terms of strategies to undo apartheid spatial planning, but further expansion of transport links will require the widening of major roads, potentially displacing informal trading hubs.

It is a typical township area in that a large proportion (38%) of the working age population is unemployed and the majority of households (78%) report a monthly income of R3 200 or less making them eligible for subsidised housing (Anderson et al, 2009; Census 2011). The majority of the population (97%) is black African and very young, with almost half (45%) between 15 and 34 years, with 33% holding at least matric⁴ and 49% having completed some secondary schooling. Haysom et al (2017) identified a distinctive pattern in which the largest proportion are young adults in the 25 to 29 age band, which suggests a large population of migrants who moved in search of employment

opportunities. As many new migrants are semi-skilled or unskilled, they are mostly absorbed into the informal sector and live in informal settlements or rented informal accommodation in backyards (see Du Toit and Neves 2006). Political battles and contestation around access to housing (see Adlard, 2014), and protest action for better service delivery that often turn violent, have been a regular occurrence in the area.

This empirical research attempted to understand the interaction and knowledge flows between informal entrepreneurs and formal knowledge producers, and the 'institutional work' (Lawrence and Suddaby, 2003) required to ensure that the informal entrepreneurs were able to benefit from and use formal knowledge resources to inform their innovation. An in-depth case study was conducted using multiple participatory methods over an extended period of time, yielding much rich data that was analysed for the paper. Table 1 summarises the mixed methods and samples used, bearing in mind one form of data collection could yield data to inform a number of dimensions of the LIPS.

Source: Adapted by authors from Petersen et al (2019); Petersen and Kruss (2020).

3. Production and innovation capacity building processes	(i) Processes through which production and innovation capabilities are generated, focusing on formal and informal learning mechanisms; (ii) Information sources; (iii) Forms of production and innovation capability building (STI, DUI); (iv) How knowledge is acquired, used and diffused; (v) Whether scientific, traditional and popular knowledge are valued and used; (vi) Interactive learning among different productive actors and education and research institutions.	(i) Semi-structured interviews	18 interviews with informal traders, and representatives from local NGOs, universities and government
		(ii) Photovoice and digital storytelling	Digital storytelling: 7 informal traders based in the township, recruited in the vicinity of the innovation hub (including 2 NGO incubator programme participants).
		(iii) Participant observation	Workshops and consultative events at the innovation hub, and multiple follow-up visits and informal conversations with participants in the township.
4. National and international context	(i) Global and national competition patterns and technological regimes; (ii) Economic, technological, institutional and geopolitical contexts, thus constituting a bridge between the local, national and global spheres	(i) Desktop research (background papers)	STATSSA, local government, provincial government, research literature Workshops and consultative events at the innovation hub, and multiple follow-up visits and informal conversations with participants in the township.
5. Wider policy environment	(i) Perspectives of policies for the promotion of the LIPS	(i) Desktop research (background papers)	STATSSA, local government, provincial government, research literature
		(ii) Semi-structured interviews (iii) Stakeholder workshops	Stakeholder buy-in and consultation workshop (Approximately 40 representatives from: a national university-community engagement organisation, universities research institutes, NGOs, CBOs, students, national and local government Approximately 30 representatives from: a national university-community engagement organisation, universities, research institutes, NGOs and CBOs, students, national and local government, informal traders and formal businesses

LIPS dimension	Dimension description	Data collection methods	Sources
1. Profile of the LIPS	(i) Origin and development of the LIPS; (ii) Main actors and networks (interaction); (iii) Main products/services; (iv) Suppliers of inputs and equipment; (v) Characteristics of the consumer market; (vi) Promotion, regulation and financing activities; (vii) Knowledge infrastructure; (viii) Embeddedness (influence of institutional context)	(i) Desktop research (background papers)	STATSSA, local government, provincial government, research literature
		(ii) Semi-structured interviews (18)	18 interviews with informal traders, and representatives from local NGOs, universities and government.
2. Local socio-economic context	(i) Socio-economic characteristics of the territory in which the LIPS is embedded; (ii) How these characteristics influence the productive activities of the LIPS; (iii) Conversely, how these activities affect this territory, focusing particularly on the social dimension	(i) Desktop research (background papers)	STATSSA, local government, provincial government, research literature
		(ii) Phase 1 stakeholder workshops	Approximately 40 representatives from: a national university- community engagement organisation, universities, research institutes, NGOs and CBOs, students, and national and local government. Approximately 30 representatives from: a national university- community engagement organisation, universities, research institutes, NGOs and CBOs, students, national and local government, informal traders and formal businesses
		(iii) Consultative closing workshop	
		(ii) Semi-structured interviews	18 interviews with informal traders, and representatives from local NGOs, universities and government.
		(iii) Photovoice and digital storytelling	Photovoice: Participants who regularly engaged with local universities, with a specific focus on including community-based actors: students, informal traders, small business owners, community members and NGO founders/representatives

3.2. A survey of innovation activity in informal enterprises

The second study used a mixed methods approach, centred on adaptation of the Oslo innovation measurement design and instrument, together with informal sector survey methodologies, in a single area in one spatially defined area in KwaZulu Natal (Figure 1). The survey design and data analysis were informed by, and interpreted using, a set of qualitative studies of informal enterprises in selected sectors and areas (see CeSTII, 2020a and 2020b, for detailed explanation of the design, methodology and sampling techniques).

The field of study is predominantly peri-rural area including rural residential sections, with a population of approximately 18 500, 59% of whom are of working age (Census 2011; Community Survey 2016), slightly more females (52%) and mainly speak isiZulu. The area falls under the authority of traditional Zulu leadership, who oversee all economic and social activity (Mthandeni, 2002), in partnership with local government. Social structures, norms, values and practices are deeply entrenched in Zulu customs.

The concept of innovation adopted for the survey design is the expanded Oslo definition that includes innovation conducted 'everywhere' (Gault, 2018):

...innovation is a new or improved product or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process) (OECD, 2018).

The challenge of creating a business register for the innovation survey sample was resolved by using a Small Area Census approach to identify all the businesses in the spatially defined area, followed by an innovation survey of all the businesses thus identified. This method yields a rigorous, statistically valid sample across all industrial sectors in the local area. The aim was to measure innovation in informal enterprises in line with standardised global methods but adapted to be able to analyse the specific forms and patterns of their innovation activities more effectively.

The survey instrument design was informed by a digital storytelling process with informal enterprise owners in the local area, to adapt survey dimensions and items. The quantitative data analysis was complemented by case studies of the local innovation and production systems that developed around two of the largest sub-sectors: food and clothing (CeSTII, 2020a; CeSTII 2020b; Petersen 2021).

A total of 271 (27%) of 996 informal businesses surveyed reported food production and services as their main economic activities. Thirteen semi-structured interviews were conducted with food business owners, face-to-face and telephonically, depending on their availability and preference, to investigate the history of the business, how it developed over time, and the

nature and role of innovation and learning. Figure 1 depicts how the three stages of the study were inter-connected and triangulated.

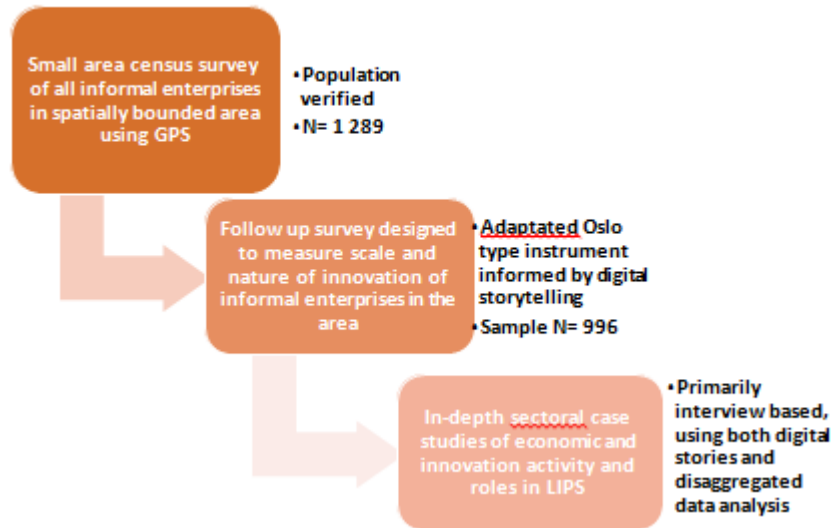


Figure 1. Study 2: Methods and samples

The survey data provides insight into the nature of informal enterprises, their owners and employees (CeSTII 2020a). Informal sector enterprises produced a turnover of R25 979 367 in goods and services in 2018. That means that each employee generated R12 100 in 2018 on average across all industries. They employed 2 147 persons (including the owners) in 2018, an average of 2,2 employees per enterprise. The majority were at least three years old, with 26,3% older than ten years.

Most commonly, they offered food (27,2%), building (17,4%) and haircare and cosmetics (15,0%) services in the local area. The typical working person (whether employee or employer) was an isiZulu-speaking (98,2%), black African (98,5%) male between the ages of 18 and 35 (43,0%). The fraction of female owners was 44,4%, and females comprised less than a third (29,8%) of employees. Levels of formal education and training qualifications were low, and the majority did not complete the full twelve years of schooling that allows access to post-school education and training.

4. Innovation, knowledge and learning in informal food enterprises

This section draws on the study of informal food enterprises in the peri-rural area, to map the food services local innovation and production system (Figure 2), and to demonstrate the scale and embedded nature of innovation, learning and types of knowledge.

4.1. Mapping the actors in the informal food LIPS in the area

Informal food trade accounts for a significant proportion of economic activity in the area, contributing to food security by offering affordable food options for low-income and impoverished households. The provision of traditional foods not available elsewhere provides competitive advantage for many businesses. Figure 2 summarises the actors in the food local innovation and production system, illustrating the wide range of economic activities, including food production, preparation and retail. Table 1 in Appendix B describes the characteristics of the employees in each of these food sub-sectors.

Most of the informal food enterprises were started out of necessity. Participants in the survey reported that they started their enterprise due to unemployment (65.7%), or to meet the basic needs of the family (36.9%). A large proportion also indicated that they decided to open a food business because they liked the activity (43.2%) or because they had the skills required (26.9%). In general, barriers to entry are low, requiring little start-up capital and medium- to low-level skills (Bhorat et al, 2016; Tawodzera, 2019; Skinner and Haysom, 2016; Skinner, 2019), making food services an attractive livelihoods option.

By far the majority of the customer base was drawn from individual households (94.5%), with small proportions of customers from government, formal enterprises and other informal enterprises. Most households buy non-perishable items and staples in bulk from supermarkets monthly, which tends to coincide with the payment of social grants and monthly wages, and rely on informal enterprises when they want to buy food on credit during the month, when they do not have money. A large proportion (44.3%) of the customers were located within the local neighbourhood, illustrating this local embeddedness, and their significance in providing low-income consumers access to affordable food options.

The main suppliers were from formal enterprises (35.4%) and households (52.8%). Typically, formal suppliers to the informal food enterprises would be low-price retailers in the local area or nearest town. Few suppliers were found at a distance from the local area, with around a third (32.8%) located within a main city in the province, but very few (less than 3%) elsewhere in the province, the country, or outside the country.

4.2. A high rate of innovation in informal food enterprises, taking distinctive incremental forms

The nature of innovation is distinctive, reflecting the prevalence of forms of imitative local learning, mainly from customers, and to a lesser extent, suppliers and other businesses as knowledge sources. Table 2 analyses the nature of innovation, knowledge and learning in the left hand column, with the right hand column reporting the most common types of activity, as well as small but potentially significant trends. Source tables for the data summarised here are included in Appendix B.

Informal food enterprises need to innovate continually, to be able to respond to customer demand, but also, to provide a good or service that will stand out from many other similar enterprises in the local area, and from large formal competitors. Technological change is incremental, and innovation typically has a low degree of sophistication or novelty. Hence, marketing activities relied strongly on 'know-who' in the area.

Doing, using and interacting (DUI) modes of product innovation prevail, rather than science and technology intensive modes. Nor were formal sources of knowledge widely used. Learning while conducting everyday business operations, through customer feedback and experimentation, was valued most. Likewise, skills and training for employees were largely developed through informal learning channels, on-the-job.

Enabling activities for innovation are mostly centred on tacit 'know-how' and 'know-who', with the most frequently reported innovation activity being responding to customer demand, given the relatively high rate of customer interaction required in the food industry. Embodied 'know-how' was also significant, with many acquiring tools such as buying a fryer to allow for the sale of hot chips or a cash register to improve the management of sales.

In contrast to the strongest trends and patterns, there is evidence of different kinds of innovation capabilities in a small proportion firms, who source new forms of knowledge and technology in more STI or 'know-why' modes, or learn through adopting new digital technologies, or use more formal channels of learning.

Table 2. Patterns of innovation and learning in informal food services enterprises

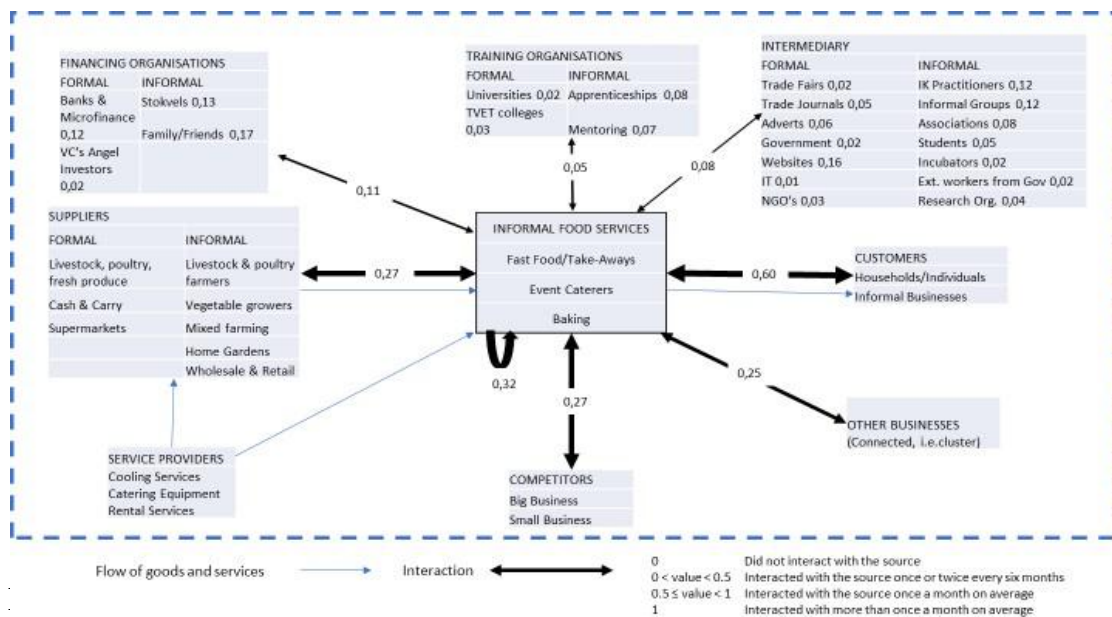
High levels of mainly process innovation activity	Any form of innovation activity 86% Process 82% Product 67%
Innovation with a very local ⁵ degree of novelty	New to local area 28% New to local industry 27%
Doing, using and imitating modes of innovation prevail	Learning by using (72%) Doing everyday working tasks (52%) Imitating products of formal enterprises (44%) Learning through interaction (28%) Using scientific and specialised knowledge (15%)

Innovation activities centred on customer-demand	Responding to customer demand, based on their feedback (72%) Acquiring tools, machinery and equipment (56%) Finding new suppliers of raw materials and tools (51%) 'Happy accidents' (38%) Changes to buildings, vehicles or other infrastructure (33%) Training staff to introduce changes (30%) Searching for new knowledge (28%) Bringing in know-how or other types of knowledge (27%) Using indigenous knowledge (26%) Change or upgrade technology (tools) (20%) On-the-job learning (15%) Engaging in a formal apprenticeship system (14%) Bring in internet and digital devices (12%)
Informal learning and few collaborative linkages	Working with new equipment or raw materials (50%) Observing and copying other businesses (41%) Learning on the job (31%) Learning to meet quality standards (32%). Work with employees to develop skills through formal channels (19%)
Marketing activities rely strongly on 'know-who' forms of knowledge	Word-of-mouth (82%) Telling family and friends (64%) Use bigger and newer signs (18.5%) Use the internet or cell phone applications (16%)

4.3. Low levels of learning through linkages

Linkages and connections within the local production and innovation system are vital for collective learning and building innovation capabilities. Figure 2 maps the strength of interaction with each type of actor in the food services LIPS⁶.

In general, interaction within the LIPS was very weak. Interaction with knowledge actors and intermediaries outside the production value chain was almost non-existent, signalling that interacting to gain formal 'know-how' and 'know-why' is the exception.



Note: The strength of interaction is reported using an index ranging from 0 to 1: 0 = Did not interact; 0 to 0.5 = Interacted once or twice every six months; 0.5 to 1 = Interacted once a month, on average; and 1 = Interacted more than once a month, on average.

For the informal fast-food and catering businesses, and the groceries and beverage retail traders, the strongest linkages were with their customers (0.60 and 0.53 respectively), to better meet customer needs. The second strongest linkages were with other businesses, particularly similar businesses within a cluster. About a third of the fast-food and catering (37.7%) and grocery retail (31.9%) businesses reported being part of a cluster. However, on average, this interaction was limited to once or twice a year, limiting opportunities for learning within a cluster.

4.4. A weak customer driven local innovation and production system

In summary, the survey data highlights a weakly integrated, customer-driven and locally embedded informal food innovation and production system in the peri-rural area. High rates of innovation of a very specific nature were found, with innovation activity driven mainly by the need to respond to changing customer demand. The strongest knowledge linkages were with customers, and linkages with knowledge actors were virtually non-existent. Innovation in these informal enterprises involved a process of learning by trialling changes and incremental adaptations, in a very competitive market. Innovation activities were mainly non-technological and 'imitative' in nature (Kraemer-Mbula et al 2019), often taking the form of 'everyday' activities in 'everyday settings' (Hoffecker 2018), supported by procedural forms of knowledge.

These kinds of innovation activities are commonly thought to be ‘insignificant’ and not relevant from an industrial development or jobs growth perspective. Nevertheless, in that they enable informal food enterprises to survive over time, such innovations are critical. It is important to develop technological and organisational capabilities to absorb and modify technologies and products, even if only new to the firm, to maintain the competitive edge in local markets, and to build employing and productive enterprises (Kraemer-Mbula et al 2019).

Developing informal enterprise capabilities for innovation is central to building collective capabilities in the local innovation and production system. If correctly supported, innovation may lead to business evolution, growth of opportunity in local markets, and stronger backward and forward linkages in value chains that can contribute to transformative change. The next section elaborates this claim, through a systematic in-depth analysis of the innovation strategies of informal food enterprises, and their associated capability building processes.

5. Capabilities for innovation and learning

The analysis in this section is based on qualitative data, drawn largely from the township food enterprises, with corroboration of trends from the peri-rural case, to understand how locally embedded institutions shape learning and innovation. The challenge is to understand how larger proportions of informal enterprises may build the innovation capabilities that can break necessity-driven path dependencies, through adoption of more opportunity-driven strategies.

5.1. Innovation capabilities through necessity- and opportunity-driven innovation strategies

Drawing on the conceptual framework set out in Section 2, and using the empirical trends highlighted in Section 4, two innovation capability pathways are identified, linked to the two main sets of innovation strategies: survivalist or necessity-driven innovation strategies, whereby enterprises make minor adaptations to existing offerings that help them to survive; and an opportunity-driven strategy. Necessity-driven innovation strategies are most common and contribute to building foundational capabilities for innovation. However, necessity-driven strategies constrain the potential for informal businesses to contribute to the kinds of diversification and complexity in production activities that is needed for growing financially viable, sustainable businesses and decent jobs in their local innovation and production systems. The opportunity-driven strategy is potentially transformative, although less common, and it is instructive to examine how some informal enterprises do grow in complexity.

The two innovation strategies lead to different levels of innovation capabilities, expressed in the degree of novelty of innovative goods and services produced by informal enterprises. For building a local innovation and production system it is important that the enterprises display diversity in innovation capability,

enabling greater levels of diversity in innovative goods and services produced. This kind of diversity requires differing degrees of complexity of knowledge combinations, which are linked to different modes of learning, rooted in deeply entrenched social norms, values and beliefs that shape entrepreneurial practice and innovation activity. Building on Table 2, the differences between the two innovation strategies and their associated innovation capability-building processes are summarised in Table 3, and elaborated in Sections 5.2 and 5.3.

Table 3. Innovation strategies and their associated innovation capability-building processes

Levels of capability	Competences		Modes of learning	Novelty of innovation
	Knowledge embedded in people (individual level)	Institutions (knowledge at the collective level)		
Foundational, based mainly on necessity-driven strategies	Intimate knowledge of local context, gained mainly through family and friends, sometimes through previous work experience, searching formal sources (what formal businesses do, internet); often includes elements of traditional knowledge: mainly locally-based procedural (know-who, know-how), and limited locally-based conceptual knowledge (know-what)	Regulative: informal, acceptable standards by local low-income market, low-price, convenience, flexibility Beliefs: black African South Africans are all connected as one, expressed as value of 'ubuntu', and it is expected that tangible resources are shared; ideas and knowledge should not be shared (leads to imitation, 'stealing' customers); large organisations (government, universities) are mainly sources of funding and tangible resources; informal business are small, 'hand-to-mouth', and not like larger businesses Normative: collective action (help others); business focus is to care for basic needs of the family, not-profit-driven; self-reliance (have all the resources needed for informal business)	Mainly experiential: doing, using and imitating. Interaction to a lesser extent and mainly with local actors	Mainly minor adaptations to existing offerings, processes and organisational arrangements . Low-risk and low amount of investment.
Potentially transformative, based mainly on opportunity-driven strategies	More complex knowledge: combination of intimate knowledge of local context and formal knowledge gained through interaction, and through previous work experience; often includes elements of traditional knowledge: combination of locally-based and formal procedural and conceptual (know-who, know-how, know-what, know-why)	Regulative: meeting/working towards compliance with rules and meeting standards required by formal/higher-income/external markets – high quality, reliable supply/service, compliance with formal business regulatory environment Beliefs: black African South Africans are all connected as one, expressed as value of ubuntu ; working together can lead to benefits – economies of scale, learning, new combinations of ideas and knowledge for competitive advantage as a collective; large organisations (govt, univ) as sources/resources – funding and material resources, knowledge, networks; informal businesses – grow to become formal, financially viable businesses; informal business: temporary stage, space for creativity and learning Normative: collective action and collective learning; aim to become formal, financially viable business – growing profits and benefit community (employment, social ills); actively searches for opportunities to grow business, learn	Combination of experiential and STI: doing, using, interacting (local and external actors), gaining specialised and technical knowledge (universities, colleges, NGOs, larger formal businesses)	New features into existing offerings, and new offerings, processes and organisational arrangements . Medium to high risk, and greater investment, depending on market targeted (local or global formal) and resources available.

5.2. Building foundational innovation capabilities through necessity-driven innovation

In townships and other similar resource-constrained contexts, entrepreneurship is very much shaped by the need to make money, with the little a person has, in order to meet the basic needs of the family. This norm underpins entrepreneurial practice and the kinds of innovation activity commonly found. Therefore, customers, as the sources of income, are valued most as key sources of information for innovation. Box 1 provides rich examples of such necessity-driven informal food businesses, that complement the trend data elicited in the survey.

In building foundational innovation capabilities, informal enterprises draw mainly on procedural knowledge. They may use conceptual knowledge to a limited extent, and this tends to relate to intimate knowledge of the local context such as the needs of low-income households, knowledge of traditional foods preferred and how to cook them, pedestrian traffic guiding where to locate the business, and so on. They gain this knowledge mainly through the day-to-day operation of the business, observing and imitating other businesses, and through gaining feedback from their customers. They respond by making

very small changes to their existing products, processes and organisational arrangements, to better meet customer needs.

When we consider the institutions guiding their learning and innovation activity, we find that they see their enterprise as more of a 'hand-to-mouth' business, and they tend to follow informal rules for doing business in the local market. As one participant in the township reported:

...how business is done here, is really different to how business is done in [the city]...sometimes the business people, some of them, it can feel like, they are doing you a favour. I think sometimes, the lack is their attitude and their approach. (university representative interview cited in Petersen and Magawana, 2019)

Informal businesses following necessity-driven strategies therefore do not identify a need for investing time and effort in seeking out sources of knowledge and interaction with others. In general, little value was placed on interacting with universities, colleges, other formal knowledge producers. For example, informal fruit and vegetable sellers identified a knowledge gap relating to finding innovative cheap ways to store and display fresh produce during the hot summer months to reduce spoilage. Addressing this gap requires scientific knowledge or 'know-why' (Lundvall, 2016: 112), but none expressed the need to find solutions through interaction with formal knowledge producers. Formal knowledge was not valued as much as the practical knowledge or 'know-how' they learned on-the-job through trial-and-error or observing other businesses. Universities were identified as potential sources of financial support rather than as knowledge partners helping to solve business challenges.

Learning through interaction with other informal traders or collective learning was also not a norm among the mainly necessity-driven informal businesses. In the township and the peri-rural area, informal traders selling similar products often clustered along the same street or in the same area. The clustering can be seen as an outcome of imitation, which is an important learning strategy. However, the high levels of imitation hindered the exchange of knowledge and ideas. Fierce competition and 'stealing' of ideas were reported as constraints to sharing ideas and knowledge. For example, lack of trust hindered knowledge sharing and learning in formal training programmes offered in the township innovation hub, as reported by one trader:

Most of them [in the training programme] are Black Africans and you know how jealous they are about sharing ideas. We don't talk about our businesses...I always tell them...You can't steal someone's talent. If I see that someone doesn't know something that I know I always share it with them (food trader interview cited in Petersen and Magawana, 2019).

Language differences and a lack of cohesiveness were other contributing factors. The township is made up of a mix of people from diverse cultural

backgrounds and geographical regions – including neighbouring African countries, and rural areas and homelands created during apartheid – who moved to the township in search of jobs and livelihoods opportunities in the city nearby.

Nevertheless, while lack of trust hindered collective learning, norms and values related to the spirit of ‘ubuntu’, of the collective good, prevailed, so that traders valued sharing tangible resources and supporting each other when in need, with the assurance that there would be reciprocal support. For example, fruit and vegetable sellers would share their stock, and often provided goods on credit to customers who ran out of money in middle of the month.

Although collective action is crucial for doing business in the kinds of resource-poor context where informal enterprises operate, operating as a collective did not always result in collective learning. While they may share some resources such as transport, this collective value does not extend to sharing knowledge resources.

Box 1. Examples of necessity-driven informal food enterprises

An example of a typical informal food enterprise is a fruit and vegetable street vendor, who operates along the pavement close to the entrance to a local shopping mall. These enterprises are rooted in local culture, in that they sell culturally valued produce in convenient locations, in small quantities for low prices. Their infrastructure may be portable and very basic – a small ‘table’, plastic container filled with water to keep the vegetables cool, an umbrella and a chair. The infrastructure provides little weather protection, nor protection from spoilage during the hot months, given the lack of access to cold storage facilities. Traders are forced to buy small amounts of stock from a large local fresh produce market or local supermarkets a number of times per week, as they sell existing stock, which raises transport costs, and in turn, lowers their profit margins. Some are forced to rely on public transport, while others pay other traders to transport them, or manage to acquire their own transport. As vendors grow the business, they may upgrade to small makeshift and fixed structures constructed from timber and corrugated sheeting.

These food traders operate in a very competitive local innovation and production system, competing with other informal traders and with large supermarkets and local shops that have begun to identify townships as lucrative markets (see Petersen et al, 2019). Inter-connections between supermarkets and informal traders do not only relate to the supply of stock, but include ‘spatial relationships of opportunity, the exchange of knowledge and innovations, and collaboration in business strategies’ (Charman et al 2019: 7). Supermarkets sell similar products in direct competition, so that informal traders find it difficult to compete: ‘Big businesses get big discounts in the

market because they buy in bulk. That is why they always beat us in terms of price' (Cited in Petersen and Magawana, 2019).

Another typical example of survivalist informal enterprises is a small tuckshop located in the owner's home, perhaps only opened in the evenings after the owner returns from a full-time job. In response to flagging sales, the owners innovate by adding a new product (for example, fried chips), based on customer demand and as a result, sales may increase.

Informal enterprises following mainly necessity-driven innovation strategies rely on less sophisticated knowledge combinations, and learn mainly through imitation and trial and error. They may grow to employ people on a part-time basis and informally, but their limited capabilities for learning and using new combinations of knowledge, and the simplicity of their innovations, mean that in such precarious and highly competitive operating conditions, they are not able to thrive, but only to survive.

For these enterprises, growth was constrained by serving a mainly low-income market without being able to rely on economies of scale. Unlike in larger, formal enterprises, investment in research and development could not be recovered by raising the price of goods and services. One strategy was to engage in another economic activity, such as using their transport to deliver produce to other traders in the area, to offer transport services to schools or to sell other goods such as cooked traditional foods to commuters on their way home. Diversification is a key innovation strategy for survival, which relies primarily on 'know-what', particularly in relation to an intimate knowledge of the local context and customer needs, and 'know-how' knowledge.

5.3. Building potentially transformative innovation capabilities through opportunity-driven innovation

Some informal enterprises develop the kinds of capability described in section 5.2, but in addition, evince signs of capabilities of a more sophisticated degree of innovation drawing on more complex combinations of knowledge. These enterprises still tended to value experiential learning, but recognised the added value to be gained through forming linkages for accessing knowledge that complements or augments their own existing knowledge.

Many gained knowledge through working in the formal sector, providing exposure and opportunity to internalise standards, norms and practices valued in the formal sector. Such unique knowledge and institutional combinations contribute to their capabilities to engage in more sophisticated innovation to grow into profitable, sustainable businesses. Some tended to remain constrained by the bounds of the local, mainly low-income, market, while others leveraged their local know-what, know-how and know-who knowledge to enter formal value chains. The capability-building processes of such

opportunity-driven informal food businesses are discussed in more detail below.

5.3.1 Capabilities to leverage traditional knowledge for innovation to grow locally-based niche markets

For these enterprises, innovation remains very incremental but can involve new goods or services offered to a niche market in the LIPS. These traders use their 'know-how' combined with symbolic knowledge of traditional food tastes, to offer prepared food products (see Box 2 for an example of such an informal food trader). They may adopt strategies of searching the internet, to solve problems and come up with new ideas to improve their goods and services. They may search for ideas and solutions through linkages with previous employers and formal knowledge producers, such as small business development NGOs. The products may not be entirely new in the local area, but they can attract a niche market, even from outside the local area, as news of a speciality traditional delicacy may spread. Selling cooked foods requires larger amounts of start-up capital and cash flow, which is typically accessed by borrowing money from family and friends or drawing capital from personal savings. Valodia and Devey (2010) found that households with a member in formal employment were more likely to be able to afford to support another member to establish an informal enterprise (see also Petersen and Charman 2018).

This 'know-how' and symbolic knowledge places these traders at a relative advantage, as the local supermarkets have not succeeded in capturing the traditional cooked foods market in townships or peri-rural areas (Petersen et al 2019). For example, a large supermarket in the township attempted to compete for a share of the traditional foods market by selling braaied meat and sheep heads, but most consumers still prefer informal food traders that use traditional meats cooked in traditional spice blends using traditional methods of cooking (Charman et al 2019). Informal cafés/take-aways, restaurants and caterers that focus on traditional foods are still able to compete in the low-income market, based on their stronger 'know-what' understanding cultural tastes and traditional 'know-how'.

Box 2. Example of an opportunity-driven informal food business that builds innovation capabilities to grow locally-based niche markets

An example is a trader who sold braaied meat, cooked on a grid over a fire from a small makeshift structure located amongst residential homes on a high foot traffic route. There was too much competition from similar enterprises. A relative suggested she should sell a new product to differentiate her enterprise, a traditional liver recipe, which led to improved sales. She then learnt through interacting with customers that the liver was too dry, and needed a sauce, which was difficult to do with the equipment and methods being used. The

trader then designed a special pot similar to traditional pots used to cook liver, and using her 'know-who' knowledge, contracted a local iron-monger to manufacture the pot. Once the new equipment was used, sales grew and the business became sustainable. This case illustrates the innovation strategy of experimentation through trial and error, but drawing on traditional 'know-what' and 'know-how' with the kind of technical knowledge required to produce a traditional pot. The business grew in size, to employing more people from the local area and expanding the business premises to include a seating area

However, it was not easy to grow the business in terms of turnover or employees. Further investment in more complex combinations of knowledge or learning would not be profitable in the low-income context, and hence, there are limits to what is possible. The strategy again is diversification – for example, the owner in Box 2 planned to let a relative run this business, while she would open a second business (see also Petersen and Charman, 2018). This example shows how innovation strategies may contribute to the circulation of money and economic opportunity to uplift families at the lower end of the poverty scale.

5.3.2. Capabilities to grow a business and link into formal value chains

Further along the continuum, informal enterprises who combine more complex forms of knowledge, have stronger institutional skills and agency, and the ability for collective learning and interaction within the LIPS, were more likely to traverse an opportunity-driven trajectory and grow a sustainable business. We found only one such informal food business in our data.

The learning and capabilities were best articulated by one informal prepared foods trader:

In 2008, I got a job as a chef at the ... hotel. Every day I prepared fresh fruit salad and vegetables. I was in charge of the shift and I loved the work. While I was there, I got an idea of providing these healthy meals in my community. But I didn't know where and how I was going to do that as it was going to be something new...I met a lady who works for which is an NGO in...Business Park...I got a coach and a mentor which helped me so much to understand my business and mostly my customers. The information that I got from them made me strong and that was when I knew I was going to run my business at...(food trader interview cited in Petersen and Magawana, 2019).

Through work experience in the formal sector, this informal trader not only gained industry know-how, but also soft skills related to know-who, such as communication, time-management, networking and effective problem-solving – all essential skills that informal traders tend to lack. She had exposure to and was able to adopt norms and values such as having a positive attitude, showing enthusiasm, and valuing reliability and adaptability. She also built relations

with customers and suppliers in the formal food industry, which, together with her intimate knowledge of the social context helped with identifying opportunities for growth and entry into the local value chain. An advantage for this informal trader, over others who migrated to the area, is that she grew up in the township, and was able to develop a deep understanding of the local consumer market, including their needs and preferences, buying trends and pedestrian movement patterns as well cultural practices, norms and values. She also had a relatively higher level of formal education, having completed high school, and several short courses to improve her business management skills.

Informal traders typically face a challenge to acquire the necessary knowledge to manage their own businesses, to do their own costing and financial management, marketing, and so on. For these kinds of know-how, a few were able to turn to formal knowledge producers, for example at the innovation hub, incubators or through NGOs. This healthy food trader too, used know-who and know-what of traditional tastes in the township, but attempted to draw on formal know-how and know-why gained from learning through a training programme for informal traders, and taking premises at the business incubator, where she could have ongoing support and broaden her customer base to serve employees and visitors of the innovation hub and nearby shopping complex. She drew on know-why knowledge of nutrition and dietetics to create a market niche for healthy foods, in a context of widespread prevalence of diseases caused by unhealthy fried foods. She opened a café that specialised in healthy foods and healthier versions of traditional foods, an innovation new to the local industry. She offered catering services in the local community and became the preferred caterer to the innovation hub where regular events were hosted, attracting guests from the nearby city, across South Africa and from foreign universities.

This required and facilitated stronger linkages in the LIPS, for example, the business supported small suppliers in the area, and sourced fresh produce from informal fruit and vegetable sellers and a community garden initiative, creating a virtuous circle and flows of value within the area. She was also able to interact with the innovation hub as a supplier of healthy catering for events they hosted, building linkages into the formal value chain. She promoted and relied on collective learning, by sharing knowledge and working together with other traders, sub-contracting them to do catering during very busy periods. Collective action and learning were used to solve problems. For example, informal traders operating from the innovation hub attempted to work around the constraints of lack of marketing know-how and funding, by collaborating to produce pamphlets that they could use to advertise their businesses in the local area.

This informal enterprise developed innovation capabilities to navigate an opportunity driven pathway, but under the impact of the COVID pandemic, it was difficult to remain viable. A lack of access to government support

programmes for informal businesses was one major constraint, particularly during hard lockdowns where no trade was permitted. This is but an extreme instance of the vulnerability to shocks.

Other limitations to growth largely relate to the presence or absence of opportunities for stronger and more linkages within the LIPS, and into the value chain outside of the local area. For example, a local development agency established a youth training project to develop skills for organic farming in an urban area. An outlet was found for the vegetables grown, in the form of a social enterprise that packaged the organic vegetables together with a recipe for quicker meal preparation, delivered to a middle-class professional market across the city. The social enterprise grew dramatically and focused on finding ways to link small-scale farmers to formal markets. However, limited attention was paid to linking with and extending opportunities to informal fruit and vegetable sellers or sellers of traditional cooked foods. Promoting opportunity driven pathways depend on opportunities to link informal enterprises into such activities, drawing on their know-how and know-what of customer demand, in combination with the know-why and scientific and technological knowledge of other actors in the LIPS.

6. Conclusion

The main contribution of this paper is an empirically grounded understanding of modes of innovation and the associated capabilities in informal enterprises. Using the local innovation and production systems (LIPS) framework led us to map patterns of innovation and analyse the kinds of innovation capabilities that exist within informal food service micro-enterprises. The conceptually informed empirical analysis furthers our understanding of the kinds of knowledge and technology resources informal enterprises draw on, their forms of learning and how these are shaped by local practices and institutions. Participatory methods were used to provide insight into the institutions in which learning is embedded, including regulative, normative and cognitive/belief systems. It remains a challenge to obtain systematic data on institutions.

A key challenge is to understand how informal enterprises may build innovation capabilities that can break necessity-driven path dependencies, through adoption of more opportunity-driven strategies. The significance of developing more knowledge intensive collaborative linkages within local innovation and production systems, across value chains and with knowledge, financial and intermediary support organisations, is highlighted. In this way, informal enterprises are able to source different forms of knowledge to support their problem-solving and innovation activities, and experiment with new knowledge combinations required for producing more sophisticated innovation towards opportunity-driven pathways. Besides sourcing knowledge externally, through interaction, informal enterprises also gain knowledge through education and training, and previous workplace experience.

The paper demonstrates that informal enterprises with necessity driven innovation capabilities require different kinds of support than those with diverse pathways towards opportunity driven innovation capabilities. It identifies the ways in which building the innovation capabilities of informal enterprises could contribute to local level diversification and potentially, to structural transformation, over time.

References

- Adlard, Gerald. 2014. Collaboration at the crossroads. The enabling of large-scale cross-sector collaborative developments. Thesis presented for the Degree of Doctor of Philosophy, Department of Environmental and Geographic Sciences, the University of Cape Town.
- Alcock, G. G. 2018. KasiNomic Revolution: The Rise of African Informal Economies. Cape Town: Jonathan Ball Publishers.
- Anderson, Valerie, Sepideh Azari and Anya van Wyk. 2009. SAEP Philippi Community Profile Final Report. Retrieved from www.saep.org, Accessed 24 May 2017.
- Andreoni, A., Mondliwa, P., Roberts, S. and Tregenna, F. 2021. Towards a new industrial policy for structural transformation. In Andreoni, A., Mondliwa, P., Roberts, S. and Tregenna, F. Structural Transformation in South Africa. OAPEN. <https://library.oapen.org/handle/20.500.12657/50510>
- Asheim, B.T., Smith, H.L. and Oughton, C., 2011. Regional innovation systems: theory, empirics and policy. *Regional studies*. 45(7):.875-891.
- BER (Bureau for Economic Research), 2016. The Small, Medium and Micro Enterprise Sector of South Africa. University of Stellenbosch, South Africa. Research Note No 1.
- Bell, M. and Figuerdo, P. 2012. Innovation capability building and learning mechanisms in latecomer firms: recent empirical contributions and implications for research. *Canadian Journal of Development Studies*. 33 (1): 14-40
- Bhorat, H., Steenkamp, F., Rooney, C., Kachingwe, N. & Lees, A. 2016. 'Understanding and Characterizing the Services Sector in South Africa: An overview'. WIDER Working Paper 2016/157.
- Cassiolato, J.E. and Martins Lastres, H.M., 2020. The framework of 'local productive and innovation systems' and its influence on STI policy in Brazil. *Economics of Innovation and New Technology*. <https://doi.org/10.1080/10438599.2020.1719650>
- Cassiolato, J.E., Lastres, H.M.M, Matos, M., and Szapiro, M. 2018. Local Innovation and Production Systems: RedeSist's conceptual framework and analytical methodology. Paper presented at the 2018 Globelics Conference, Accra, October 2018. José Eduardo Cassiolato
- Cassiolato, J.E., Lastres, H.M.M., Szapiro, M., and de Matos, M.G.P. 2017. Local production and innovation systems in Brazil: a balance of 20 years. RedeSist Working Paper TD DIT-No. 04/2017. (www.redesist.ie.ufrj.br).
- CeSTII. 2020a. Innovation In The Informal Sector Survey Statistical Report: Baseline Survey in Sweetwaters, KwaZulu-Natal, 2017-2018. Pretoria: Human Sciences Research Council.
- CeSTII. 2020b. Innovation in the Informal Sector. Food case study report. Pretoria: Human Sciences Research Council.
- Charman, A., Petersen, L. and Govender, T. 2020. Township economy. People, spaces and practices. Cape Town: HSRC Press

- Charman, A., Bacq, S. & Brown, K. 2019. "Spatial determinants of formal retailers' impact on informal microenterprises in the township context: A case study of Philippi East, Cape Town." Food Security SA Research Report Series. Research Report 002. DST-NRF Centre of Excellence in Food Security, Cape Town.
- Charman, A. and Petersen, L. 2018. "Informal Micro-enterprises in a Township Context: A spatial analysis of business dynamics in five Cape Town localities." In *The South African Informal Sector: Creating Jobs, Reducing Poverty*, edited by F. Fourie. Pretoria: HSRC Press.
- Charman, A.J.E., Petersen, L.M, Piper, L.E., Liederman, R. and Legg, T. 2017. "Small Area Census Approach to Measure the Township Informal Economy in South Africa". *Journal of Mixed Methods Research*, 11(1): 36-58.
- Charman, A., Piper, L. and Petersen, L. 2012. 'Informality disallowed: state restrictions on informal traders and micro-enterprises. Case evidence from Brown's Farm, Philippi, in Cape Town'. Paper for Towards Carnegie III: Strategies to Overcome Poverty and Inequality Conference, UCT 3-7 September 2012.
- Charmes, J. 2016. "The informal Economy: Definitions, Size, Contribution and Main Characteristics." In *The Informal Economy in Developing Nations: Hidden Engine of Innovation?*, edited by Erika Kraemer-Mbula and Sascha Wunsch-Vincent. Cambridge: Cambridge University Press.
- Charmes, J., Gault, F., and Wunsch-Vincent, S. 2016. "Formulating an Agenda for the Measurement of Innovation in the Informal Economy." In *The Informal Economy in Developing Nations: Hidden Engine of Innovation?*, edited by Erika Kraemer-Mbula and Sascha Wunsch-Vincent. Cambridge: Cambridge University Press.
- Cozzens, S., and Sutz, J. 2014. "Innovation in informal settings: Reflections and proposals for a research agenda." *Innovation and Development*, 4(1): 5-31.
- De Beer, J., Fu, K., & Wunsch- Vincent, S. 2013. *The Informal Economy, Innovation and Intellectual Property: concepts, metrics and policy considerations* (Vol. 10). WIPO.
- Department of Economic Development and Tourism, KwaZulu-Natal. 2010. *Policy for the informal economy*. "Creating an enabling environment for the informal economy".
- Department of Science and Innovation. 2021. *Science, technology and innovation decadal plan 2021- 2031*. Draft for consultation. March
- Department of Small Business Development (DSBD). 2015. *National Informal Business Upliftment Strategy*. Retrieved from <http://www.dsbd.gov.za/about-dsbd.html>
- Department of Trade and Industry (dti). 2008. *Annual Review of Small Business in South Africa 2005- 2007*. Pretoria: dti
- Du Toit, A. and Neves, D. 2006. *Vulnerability and Social Protection at the Margins of the Formal Economy. Case studies from Khayelitsha and the Eastern Cape*. Cape Town: Programme for Land and Agrarian Studies (PLAAS) at the University of the Western Cape.

- Fagerberg, J. and Srholec, M. 2010. Knowledge, capabilities and the poverty trap: the complex interplay between technological, social and geographical factors. Paper presented at the 8th Globelics Conference, Malaysia, 1-3 November. Retrieved from www.globelics.org
- Fligstein, N. and McAdam, D. 2012. A theory of fields. New York: Oxford University Press.
- Fourie, F. 2018a. The South African Informal Sector: Creating Jobs, Reducing Poverty. Pretoria: HSRC Press.
- Fourie 2018b. Creating jobs, reducing poverty I: Why the informal sector should be taken seriously and enabled properly. <http://www.econ3x3.org/article/creating-jobs-reducing-poverty-i-why-informal-sector-should-be-taken-seriously-and-enabled>
- Garud, R, Hardy, C, and Maguire, S. 2017. Institutional entrepreneurship as embedded agency: an introduction to the Special Issue. *Organization Studies* 28(07): 957-969. DOI: 10.1177/0170840607078958.
- Gault, F. 2018. "Defining and measuring innovation in all sectors of the economy". *Research Policy* 47: 617-622.
- Gauteng province. 2014. Gauteng township economy revitalisation strategy 2014-2019. Department of Economic Development, Gauteng province.
- Hartnack, A. and Liedeman, R. 2017. Factors contributing to the demise of informal enterprises: evidence from a Cape township. *Econ 3X3*. January. www.econ3X3.org
- Haysom, G., Crush, J., and Caesar, M. 2017. The urban food system of Cape Town, South Africa.
- Hungry Cities Report Number 3. Hungry Cities Partnership, African Centre for Cities, University of Cape Town, South Africa, and Wilfrid Laurier University/Balsillie School of International Affairs, Waterloo, Canada.
- ILO (International Labour Organisation). 2013. Measuring Informality: A statistical manual on the informal sector and informal employment. Geneva: ILO. http://www.ilo.org/global/publications/ilo-bookstore/order-online/books/WCMS_222979/lang--en/index.htm
- Institute for Economic Justice. 2018. Informal economy/sector. Policy brief prepared for the Labour Caucus in the Jobs Summit, Small and Microenterprise Support working group.
- Jensen, M.B., Johnson, B., Lorenz, E., Lundvall, B.Å. and Lundvall, B.A., 2007. Forms of knowledge and modes of innovation. In Lundvall, B. (Ed). *The learning economy* and Kraemer-Mbula, E., & Wunsch-Vincent, S. (Eds.). (2016). *The informal economy in developing nations*. Cambridge University Press.
- Jutting, J. and de Laiglesia, J. Eds. 2009. *Is Informal Normal? towards more and better jobs in developing countries*. Paris: Development Centre of the OECD.
- Jutting, J. and de Laiglesia, J. Eds. 2009. *Is Informal Normal? towards more and better jobs in developing countries*. Paris: Development Centre of the OECD. Kraemer-Mbula and Wunsch Vincent 2018

- Kraemer-Mbula, E., Lorenz, E., Takala-Greenish, L., Jegede, O. O., Garba, T., Mutambala, M., & Esemu, T. 2019. Are African micro-and small enterprises misunderstood? Unpacking the relationship between work organisation, capability development and innovation. *International Journal of Technological Learning, Innovation and Development*, 11(1), 1-30.
- Kroll, F., Battersby, J., Haysom, G., Drimie, S. and Adelle, C. 2021. Leveraging Informal Trade: Governance strategies to cultivate resilient, inclusive food economies, Policy Brief 1/2021. Cape Town: DSI/NRF Centre of Excellence in Food Security.
- Kruss, G. 2021. Catching up, falling behind: the need for political coalitions for innovation and inclusive development in South Africa. *Nova Economia*. 30: 1115-1144.
- Lam, A. and Lundvall, B-A. 2007. 'The Learning organisation and national systems of competence building and innovation', in N. Lorenz and B-A Lundvall (eds) *How Europe's Economies Learn: Coordinating Competing Models*, Oxford University Press, pp. 110-139.
- Lastres, H.M.M., and Cassiolato, J.E. 2005. Systems of innovation, clusters and industrial districts: analytical and policy implications of convergence and differences in the approaches. Paper presented at the third Globelics International Conference, Pretoria, South Africa, 1 November. (www.redesist.ie.ufrj.br).
- Lastres, H. M. M., & Cassiolato, J. E. 2018. The conceptual and methodological framework of LIPs: the Brazilian Experience. Paper presented at the Human Sciences Research Council- CeSTII Workshop, Cape Town.
- Lawrence, T.B. 2008. Power, institutions and organizations. In R. Greenwood, C. Oliver, K. Sahlin, and R. Suddaby (Eds.), *Sage Handbook of Organizational Institutionalism*, pp. 170-197. London: Sage Publications.
- Lawrence, T.B., and Suddaby, R. 2006. Institutions and institutional work. In R. Clegg, C. Hardy, T. B. Lawrence, & W. R. Nord (Eds.) *Handbook of organization studies*, 2nd Edition: 215-254. London: Sage
- Leca, B., Battilana, J. and Boxenbaum, E. 2008. *Agency and institutions: A review of institutional entrepreneurship*. Cambridge, MA: Harvard Business School.
- Lundvall, B-A. 2016. *The Learning Economy and the Economics of Hope*. London, South Africa: Anthem Press.
- Mahadea, D., & Khumalo, S. (2020). Understanding the Internal and External Constraints to Growth of Microenterprise Entrepreneurship in a South African Provincial Context: A Case of Mpumalanga-Mkhondo. *Journal of Developmental Entrepreneurship*, 25(2).
- Marsili, O. and Salter, A. 2005. 'Inequality' of innovation: skewed distributions and the returns to innovation in Dutch manufacturing. *Economics of Innovation and New Technology* 14(1-2): 83-102. DOI: 10.1080/1043859042000228642
- Moleko, N. and Swilling, M. 2021. New wine into new wineskins. An alternative economic strategy for South Africa's economic reconstruction. Stellenbosch: University of Stellenbosch Business School and Centre for Complex Systems in Transition.

- Morris, M, and Fessehaie, J. 2014. "The industrialisation challenge for Africa: towards a commodities based industrialisation path". *Journal of African Trade* 1: 25-36.
- Mthandeni, E. D. (2002). Traditional leaders and new local government dispensation in South Africa.
- Grenoble-Avignon: HAL. Retrieved from <https://halshs.archives-ouvertes.fr/halshs-00749691>
- Mustapha, N., Petersen, I., Bortagaray, I., Jegede, O., & Kruss, G. 2021. Measurement of innovation in the informal sector in Africa: the importance to industrial policy. *Innovation & Development*. DOI: 10.1080/2157930X.2021.1887614
- Neves, D., Aliber, M., Mogaladi, J. and du Toit, A. 2011. Self-employment in South Africa's informal sector: Prevalence, prospects and policy. Cape Town: Institute for Poverty, Land and Agrarian Studies, University of the Western Cape.
- Nübler I 2014.. A theory of capabilities for productive transformation: Learning to catch up. *Transforming Economies*. 113-149..
- OECD/Eurostat. 2018. Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris/Eurostat, Luxembourg. <https://doi.org/10.1787/9789264304604-en>
- Petersen, I., & Kruss, G. 2021. Universities as change agents in resource-poor local settings: An empirically grounded typology of engagement models. *Technological Forecasting and Social Change* 167, 120693.
- Petersen, I. and Magawana, X. 2020. An analysis of knowledge flows, learning and innovation in the informal food services local system in Philippi East. Project report. Centre for Science, Technology and Innovation Indicators, Human Sciences Research Council.
- Petersen, I., Kruss, G., Rust, R., Juan, A. and Tele, A. 2016. Is South Africa ready for "Innovation for Inclusive Development"? A systemic review across national policy. Cape Town: Centre for Science, Technology and Innovation Indicators, Human Sciences Research Council.
- Petersen, L., Thorogood, C., Charman, A. and du Toit, A. 2019. What Price Cheap Goods? Survivalists, informalists and competition in the township retail grocery trade. PLAAS Working Paper 59. Cape Town: Institute for Poverty, Land and Agrarian Studies, University of the Western Cape.
- Petersen, L. and Charman, A,. 2018. The role of family in the township informal economy of food and drink in KwaMashu, South Africa. *International Journal of Sociology and Social Policy*. 38 (7/80: 564-577.
- Razafindrakoto, M. and Roubaud, F. and Torelli, C. 2009. "Measuring the informal sector and informal employment: the experience drawn from 1-2-3 surveys in African countries." *African Statistical Journal*, 9: 88-147.
- Rogan, M., and Skinner, C. 2018. Employment in the South African informal sector: Interrogating trends, identifying opportunities, In Fourie, F (Ed). *Tackling unemployment and poverty in South Africa: the contribution of the informal sector*. Cape Town: HSRC Press.

- Schoser, C. 1999. The institutions defining national systems of innovation. A new taxonomy to analyse the impact of globalisation. Paper presented at the Annual Conference of the European Association of Evolutionary Political Economy (EAEPE) in Prague, November 4-7.
- Scott, W.R. 1995. Institutions and organisations. Thousand Oaks, California: Sage Publications, Inc.
- Skinner, C. and Haysom, G. 2016. The informal sector's role in food security: a missing link in policy debates? (discussion paper no. 6). Cape Town and Waterloo: Hungry Cities Partnership.
- Statistics South Africa. 2020. Gender Series Volume VII: Informal Economy, 2013–2019. Pretoria: Statistics South Africa.
- Stats, SA. 2016. Statistics South Africa. Community Survey.
- Stats, S.A. 2011. Statistics South Africa. Formal census.
- Tawodzera, G. 2019. The Nature and Operations of Informal Food Vendors in Cape Town. *Urban Forum*, 30: 443–459.
- Tregenna, F. 2015. Deindustrialisation, structural change and sustainable economic growth. UNIDO Inclusive and Sustainable Industrial Development Working Paper Series, WP 02. Vienna: UNIDO
- Tregenna, F. 2016. "Deindustrialisation: an issue for both developed and developing countries". In *Routledge Handbook of Industry and Development*, edited by John Weiss and Michael Tribe. London, UK: Routledge.
- Valodia, I. and Devey, R. 2010. Formal-informal economy linkages: What implications for poverty in South Africa? *Law, Democracy and Development*. 14: 1-26.
- Von Tunzelmann, N., Gunther, J., Wilde, K and Jindra, B. 2010. Interactive dynamic capabilities and regenerating the East German innovation system. *Political Economy*. 29: 87-110.
- Von Tunzelmann N. and Wang Q. 2003. An evolutionary view of dynamic capabilities. *Economie Appliquée* 56(3): 33–64.

Appendix a. Statistics South Africa Trend Analysis of those Running Informal Businesses in 2013 and 2017

“A review of the informal sector showed that there were more males than females running informal businesses. The provincial distribution of the informal businesses revealed that the highest concentrations of informal businesses were in Gauteng at 29,9%, followed by KwaZulu-Natal and Limpopo at 20,2% and 14,3% respectively in 2013. In 2017 however, Gauteng had the highest concentration of informal businesses (28,3%), followed by Limpopo (16,7%) and KwaZulu-Natal (14,5%).

An examination of the informal businesses by the ownership status within each sex category revealed that both males and females were more likely to operate their informal businesses as own- account workers even though they showed higher shares than their male counterparts. Higher levels of own-account work usually indicates higher levels of informality, under-development and poverty as people involved are unable to afford paid employees. Persons running informal businesses were more likely to be between the ages of 35–45 years old, and this was the case for both years of reporting. Similar to informal employment, over 60,0% of persons running informal businesses had their highest level of education of less than matric and that only less than 10,0% of persons who possess tertiary as the highest level of education were running informal businesses.

The main reason people decided to start informal businesses for both males and females was due to unemployment. At least 50% of them needed money to start their businesses. Of the individuals who needed money to start running businesses, males had a higher percentage of the individuals who either used their capital or borrowed money or used grant money to start informal businesses.

When looking at the monthly turnover of persons running informal businesses men had a larger share than women in the highest monthly turnover categories whilst the opposite was observed for women. A gender gap of 10,2% was observed for persons who had a turnover of above R6 001, wherein men and women recorded 22,3% and 12,1%; respectively, in 2017. The informal businesses were operated mainly from the owners’ own residences whether with or without a different space as well as from mobile platforms with no fixed areas. Above a quarter of persons running informal businesses had no electricity at their businesses which increased to 32,2% in 2017. During the review period, an increase in the persons running informal businesses that had no toilet/ablution facilities was recorded.... Furthermore, the analysis showed that there was a slight increase of 3 percentage points of the females running informal businesses without water” (Statistics SA 2020: 38).

**Appendix b. Selected Tables of Innovation in Informal Enterprises in One Area of
KWAZULU NATAL 2018**

Table 1. Description of employees in food services informal enterprises 2018

	Total employees (2018)	Employee s that completed school (2018)	Paid employees (2018)	Employee that are family (2018)	Female employees (2018)	Male employees (2018)	Increase in employee s from 2017 to 2018
Retail in livestock, poultry and fresh produce	14 (1,3)	3 (0,3)	7 (0,8)	4 (0,4)	5 (0,5)	6 (0,5)	1 (0,1)
Food and related services	217 (2,5)	119 (1,6)	164 (2,1)	64 (0,9)	94 (1,1)	101 (1,2)	52 (0,6)
Retail in groceries and beverages	316 (1,9)	114 (0,8)	177 (1,2)	102 (0,8)	95 (0,6)	156 (0,9)	95 (0,6)
Other services (to informal traders)	17 (3,4)	10 (2,5)	16 (3,2)	5 (1,0)	6 (1,2)	11 (2,2)	3 (0,6)
Total food businesses	564 (2,1)	246 (1,1)	364 (1,5)	175 (0,8)	200 (0,7)	274 (1,0)	151 (0,6)

Notes

¹ Appendix A provides descriptive data of the owners, resources and focal activities of these enterprises, to situate the analysis.

² An unincorporated enterprise, which means that:

- It is not constituted as a legal entity separate from its owners, and
- It is owned and controlled by one or more members of one or more households, and
- It is not a quasi-corporation (it does not have a complete set of accounts, including balance sheets);
- It is a market enterprise: this means that it sells at least some of the goods or services it produces.
- It therefore excludes households employing paid domestic workers;
- And at least one of the following criteria:
 - The number of persons engaged / employees / employees employed on a continuous basis, is below a threshold determined by the country
 - The enterprise is not registered
 - The employees of the enterprise are not registered.

Source: https://www.ilo.org/ilostat-files/Documents/description_IFL_EN.pdf

³ Shocks can range from relatively minor events that a more formal business could withstand, such as a fire that destroys the premises, which is common in informal settlements, to the lockdowns instituted as a strategy to contain the COVID pandemic, which has been devastating for informal micro-enterprises with few resources to fall back on

⁴ The formal school leaving qualification that enables access to higher education.

⁵ Note that this variable had a very high rate of missing responses – 44% did not provide the answer.

⁶ Each variable in a construct was normalised (to lie between 0 and 1) by subtracting one from each response and dividing the result by three. The values on the diagram for each variable was taken as the mean of these normalised values for all the enterprises in the sector. The strength of each construct was calculated as the average of the variable values within the construct

Is small always beautiful? Heterogeneous effects of small scale de-reservation on product scope and performance

George Paily, Nanditha Mathew, Carlo Pietrobelli
 UNU MERIT, Maastricht University, The Netherlands

Abstract

In this paper, we evaluate the effect of one of the unique cases of size-dependent industrial policy- small scale product de-reservation in India, on plant level outcomes of product scope, productivity and sales growth. Utilising a rich plant-level and product-level dataset from the Annual Survey of Industries (ASI), the official survey of manufacturing plants in India, we apply the Difference-in-Difference approach with multiple treatment periods and variation in the timing of treatment developed by Callaway and Sant'Anna (2021). Our results indicate that the effect of small scale product de-reservation policy is highly contingent upon the plant level heterogeneities. The implementation of product de-reservation has led to a positive effect on new product introductions and overall sales growth. The policy's effectiveness varies across plant sizes and is more evident for larger plants for new product introduction, labor productivity, and sales growth. However this differential effects is not entirely due to the size differences, but other firm characteristics and capabilities. The policy improved sales growth for incumbent firms, while positively impacting product scope and productivity for new entrants. Innovative firms benefit the most from the policy, and the positive impact of the policy is more clear for plant units using new inputs. Our findings show that not all enterprises were well positioned to get the benefits of size-dependent policies.

Key Words: Size-dependent policies, Small scale industries, product scope, Firm performance, Manufacturing, India
JEL codes: O14, O24, O25, L25, L53

1. Introduction

Protection to small scale enterprises are common especially in developing countries for a variety of reasons.¹ Small scale firms are often treated as the 'backbone' of the economy as these units are generally labour intensive and create more employment, yet the evidence to date on firm size and employment growth is inconclusive (Van Biesebroeck, 2005; Haltiwanger et al., 2013). Along with the employment side, supporters of small scale units' protectionism also argue in terms of mitigation of capital market imperfections, shifting income in favour of low wage earners and so forth (Hussain, 1997). India, the focus of this paper has had extensive regulations in place to promote small and medium enterprises (SMEs) as part of its socialist legacy. Though, the promotional measures have included the types of policies used globally such as credit, capital and power subsidies, technical assistance, tax exemptions, preferences in government procurement etc, the main element of promotion of SMEs targeted products rather than firms. In other words, until 1997, the premier instrument for protecting SMEs in India was reserving a number of products for the exclusive production by small scale units and this could be considered as one of the unique cases of size-dependent policy all across the countries.

The antagonists' side of the small scale industry protection raise concerns that mis-allocation of inputs from high to low productivity firms and industries is an important driver of productivity losses (Hsieh and Klenow, 2009). A growing body of literature find that such regulations reduce aggregate productivity by restricting the growth of productive enterprises (Restuccia and Rogerson, 2008; Bento and Restuccia, 2017; Guner et al., 2008). In this sense, small scale reservation policy in India might have discouraged the firm growth and slowed down the overall expansion of the manufacturing sector. For example, Mohan (2002) argues that small enterprises making reserved products were discouraged from growing and upgrading their technology, as they were allowed to manufacture the reserved products unless their investments go beyond the allowed limits for SMEs. Further, as hypothesized by Panagariya (2008), the policy of reserving many products for exclusive production by SMEs acted as a hindrance for expanding the Indian exports of these products. In addition, as scholars including Bertrand and Kramarz (2002) argue, the small scale enterprises also fail to protect employment, deter investment and technology upgrades. Consistent with the observations raised by these studies, the episodes of product reservation system in India also resulted in sub-optimal firm size and with substantial productivity and output loss in reserved markets as well as non-reserved markets with its linkage effects (Garcia-Santana and

Pijoan-Mas, 2014). These insights have prompted the Indian government to review the small scale product reservation in India and henceforth, the policy was withdrawn in a phased manner starting from 1997. However, there are limited evidences on how plants have responded to this policy change with respect to product scope and performance outcomes.

Some of the recent studies dealing with dismantling the small scale reservation look into the impact of policy change on establishment outcomes - output, employment, wage and investment etc. Departing from previous studies, we enquire into the impact of product de-reservation on establishments' product scope and performance outcomes and how this dynamics work for heterogeneous firms. Even though, SSI de-reservation is mainly applicable for small firms in terms of capital threshold, it's effect may not be uniform across firms as these firms are heterogeneous in different characteristics such as productivity (Melitz, 2003; Melitz and Ottaviano, 2008), cost structure (Pan and Wang, 2020), technological and managerial capabilities (Gifford, 1993) etc. In general, tiny plant units are more likely to use labour intensive methods of production whereas other enterprises could be more capital intensive. Therefore, these units, though they are collectively referred as SMEs for the eligibility of product reservation, they are expected to be heterogeneous and may operate under different production possibility frontiers and hence different potential product scope and performance. Further, much celebrated theories in firm growth and strategic management literature including Resource Based View (RBV) also supports the view that heterogeneity in resources are essential though enterprises belong to same definitional categories (Barney, 1991; Wernerfelt, 1984; Peteraf, 1993). As Arbelo et al. (2022) observes, SMEs can be very heterogeneous in both cost and revenue efficiency, which may affect performance outcomes such as product scope and productivity.

In the product reservation regime, a plant whose total stock of investment in plant and machinery at historical cost is less than INR 10 million was considered as a SSI (small scale industry) unit and allowed to manufacture product(s) which is categorised as SSI products. By the Micro, Small and Medium Enterprise Act (2006), this limit got raised to INR 50 million.² However in terms of number of employees as the standardised measure of size, a study on the effect of SSI de-reservation involves plants that are small as per SSI definition but large in terms of number of employees. We believe that product de-reservation policy might have differential effects on product scope and performance of plants with different size class in terms of employment.

The heterogeneous effects of de-reservation policy may not be limited to size class alone. Once the de- reservation policy has been implemented, many establishments could enter into the SSI product space. These new entrants might be different in capabilities compared to incumbents and could benefit more from this policy changes. Moreover, the effect of de-reservation policy might differ for innovating and non-innovating units.

As one of the unique features of SSI product de-reservation was the targeting of products than firms, use of new inputs might contribute to an important element of firm heterogeneity due to different levels of exposure and capability differences. The predecessor of SSI de-reservation was economic liberalisation especially trade liberalisation. Trade liberalisation coupled with reserved product regime resulted in protection of Small Scale Industry (SSI) units from domestic non-SSI units but facing competition from foreign enterprises as these products were allowed to import with lower/no restrictions, and hence the need for policy shift towards de-reservation. The substantial lowering of import barriers that took place in India in 1990s and 2000s have increasingly enabled the Indian firms to switch some of their requirements of intermediate inputs from domestic sources to relatively lower cost foreign sources (after taking into account the quality of these inputs) and thereby providing them a cost advantage (Goldar, 2015). Further, trade reform might have benefited Indian firms not only by providing access to better and cheaper inputs (new/existing), but also crucially through imports of new input varieties (Goldberg et al., 2009). In this scenario, this study also looks how the effect of product de-reservation gets varied for plants that use inputs compared to others and for importing units compared to non-importers.

We use the recently made available plant-level panel dataset from India's Annual Survey of Industries (hereafter, ASI). While this dataset was previously available as repeated cross section, the new dataset provides unique identifiers for plant units allowing us to establish the link from the beginning and end of the accounting year. This paper finds that, though the effect of de-reservation is positive at the overall level, the effect of de-reservation is not uniform across plants firstly with respect to labour size class. We observe that the positive effect of de-reservation is statistically significant for large plants, but not for the tiny plant units. However this dynamics cannot be explained only with respect to plant size alone, but enterprises characteristics and capabilities play a role appropriating the benefits of policy changes. Innovative firms benefited more from the product de-reservation over non-innovators. Moreover, we see that the effects are heterogeneous for incumbents and new entrants. Our results also show that for the plants that use new inputs, the positive effects of product de-reservation is clearly evident over the plants that do not use new inputs.

This study is expected to contribute to the existing stream of literature on innovation and SMEs development in India. Moreover, the study has several policy implications especially in SME policies and National Science, Technology and Innovation policies. The policies in general aimed at small scale industry units might have very much differential effects based on plant characteristics and exiting capabilities. The rest of the paper is organised in the following manner. Section 2 provides the background of small scale products reservation and de-reservation in India. Section 3 describes data, variables and provides summary statistics of the relevant variables. Section 4 details the methodology

including econometric specification used in the study. In section 5, we present the results of this study. The last section concludes the paper with a brief discussion.

2 Small Scale Industry (SSI) reservation and de-reservation in India

India, the focus of this paper has had extensive regulations in place to promote small and medium enterprises (SMEs) as part of its socialist legacy after independence, with the primary objectives of employment generation and promoting equity. In this way small scale industries (SSIs) have historically formed a large part of the Indian manufacturing sector contributing to more than 40 percent of the manufacturing output and 35 percent of the employment.

Among the myriads of support systems for the SSI units, arguably the most prominent and unique policy was the small scale product reservation, implemented in the 3rd Five year plan (Tewari and Wilde, 2019). Until 1997, this policy continued as the premier instrument for protecting small establishments in India. Under this policy, hundreds of products from primary sector to chemicals were reserved for the exclusive production by small scale industry units. The reservation policy started in 1967 with 47 products, which increased to 504 in 1978 and to 836 in 1989 (Sen and Ray, 2015). By the year 1997, the number of products got under SSI reservation reached its peak of around 1000. The consideration for reservation of an item is its suitability and feasibility for being made in the small scale sector without compromising on quality aspects (Velayudhan, 2004).

Studies argue that these regulations placed the economy in sub-optimal conditions of production and slowed down the potential economic growth. Aghion et al. (2008) is one of a few notable studies on the cost of regulations in India that show how licensing had significant but heterogeneous costs for both growth and productivity. The study further by developing models observe that dismantling of license raj encourages firm entry and expansion among more productive firms as well as exit and contraction of less productive firms with more pronounced effects in regions with more labour costs. The inefficiencies and loss of output and productivity prompted the Indian government to gradually relax the policy of protection via product reservation to a policy of promotion with adequate supply of credit facilities, technology assistance and low transaction cost.

A relatively recent paper by Garcia-Santana and Pijoan-Mas (2014) calibrate a span of control models that account for the reservation policy using the data from 2001, when most of the product reservations were still in place. They simulated the effects of removing the reservation policy and predict that doing so would increase manufacturing output per worker by nearly 7 percentage. Martin et al. (2017) identify that the simulation results provided by Garcia-Santana and Pijoan-Mas (2014) is pretty much close to reality. Further Morris et

al. (2001) provide evidence from a survey of around 1200 small scale units that the growth of output of reserved products is significantly slower than that of non reserved items produced by the small enterprises. A later study by Debroy et al. (2006) arrives at some of the broad characteristics of reserved product space that the units producing reserved goods are only one fifth of the total small scale industries and they account for only one sixth of the SSI's total employment. Moreover, the output is merely 12 percent and contribution to exports is less than 5 percent. According to Hsieh and Klenow (2009), almost half of the productivity gap between some developing economies like India and the US is due to plant level distortions and these distortions occurs through mis-allocation of productive resources backed by the government policies that impose barriers on the size of firms to promote smaller ones.

Though previous studies attempt to examine the effects of de-reservation policy, there is a scant attention for the dimension of how this effect varies based on firm characteristics including size, capabilities etc. These programmes are primarily intended and expected to benefit smaller establishments. As of MSME report 2008, the objective of progressive de-reservation was to provide opportunities for technology upgradation, promotion of exports and economies of scale in order to encourage modernisation and enhance the competitiveness of small enterprises in view of the liberalisation and globalisation of the economy. Indeed, tiny enterprises are likely to be affected by greater barriers in moving to new product lines, improving productivity etc. How firms will be able to harness the benefits of these policies might depend on the existing firm characteristics and capabilities. For instance, Lewis (2005) argues that a minimum efficient scale that is required by a cloth manufacturing firm is 5000 sewing machines, however plants serving for the domestic market in India barely have 20 sewing machines on an average.

The definition of small units for the purpose Small scale product reservation was based on the value of plants and machineries at historical cost. This ceiling over investment in plant and machineries were subject to change over time and was fixed at INR 10 million ceiling was fixed in 1999 and then raised to INR 50 million by the Micro, Small and Medium Enterprise Act in 2006. Since we are not able to adopt a uniform criteria of plant size based on the investment throughout the study period, we adopt a definition based on the labour standards. Another reason for employing the definition based on number of employees as argued by a vast majority of previous researches on small firm dynamics in developing countries saying that it is often difficult to obtain reliable financial data for small enterprises (Bigsten and Gebreeyesus, 2007; Robson and Obeng, 2008; Mead and Liedholm, 1998). As argued by Nichter and Goldmark (2009), even the owners of the small establishments often do not keep written records in a systematic manner but they usually know the number of employees they have hired.

This paper is related to Martin et al. (2017) and Tewari and Wilde (2019) with respect to the effect of de-reservation on performance outcomes. However this study depart in other important directions focusing and how enterprises with their heterogeneities have responded towards the policy change of product de-reservation.

3 Data, Variable definition and Summary statistics

3.1 Data source

This paper makes a significant contribution by organizing and utilizing a unique dataset of India's manufacturing sector, drawn from plant level panel data set of India's Annual Survey of Industries (ASI). While this dataset were previously available as repeated cross section, the new dataset provides unique identifiers for plant units allowing us to establish the link from the beginning and end of the accounting year. Prior research, such as Goldberg et al. (2010a,b); Dosi et al. (2020), has utilized the CMIE-Prowess database, created and maintained by the Centre for Monitoring Indian Economy (CMIE). While this database has been useful for studying the behavior of large firms in terms of pricing, mark-ups, privatization, firm size distribution, innovation, technological activities, product switching, and firm dynamics, the ASI data offers a more comprehensive view of the organized or registered component of Indian manufacturing.

The ASI dataset covers industrial units registered as 'factories' under the Factories Act 1948 and includes all manufacturing units with more than 10 workers using electricity or 20 workers with or without electricity. The sampling universe for the ASI consists of factories registered under 2m(i) and 2m(ii) of the Factories Act, units registered under the Bidi and Cigar Workers Act, and several utility providers. Although the data-set includes larger factories with 100 or more employees, it also covers smaller factories with fewer employees, albeit less frequently³. Furthermore, our dataset often includes enterprises that may be larger in terms of labor but are small with respect to capital investment, adhering to the SSI standards. A noteworthy feature of the ASI dataset is that it provides product-specific information on inputs, including both imported and domestically purchased items, as well as products manufactured.⁴ This detailed data, spanning from 2000-01 to 2015-16, is particularly well suited for understanding how establishments adjust their product portfolio and input usage in response to SSI de-reservation policies as product dereservation began in late 90s.

The period from early 2000s has been characterized by a remarkable surge in aggregate production and productivity in comparison to previous decades, as highlighted by studies such as Goldar (2015). In fact, the trend growth rate in real value added in manufacturing during the 2000s was significantly higher than that of the 1980s and 1990s. This gap in trend growth rates between the

1990s and 2000s has been found to be statistically significant at a 1 percent level of significance. This also justifies the time period this study considers. That helps to offer valuable insights into the Indian manufacturing sector's response to SSI de-reservation policies and the dynamics of establishments' product portfolios and input usage.

3.2 Sample construction and concordance procedure

ASI data is subdivided into various parts called 'Blocks', which are thematic sub-units of data. To construct our sample, we use all non-missing observations from Blocks A (basic information), B (additional information), C (capital and investment), D (finished goods), E (employment), G (receipts), H (inputs, including fuel and electricity), I (imports), and J (production). We restrict our sample to manufacturing plants, i.e., industries 15 to 36 of India's NIC classification 2004, and drop a very small number of observations with unreliable data. Table 2 provides a brief overview of our data.

3.2.1 Concordance from ASICC to NPC-MS product codes

As mentioned, the basic unit of the ASI is an 'establishment', otherwise called as 'factory' in the ASI dataset. From 2000-01 to 2009-10 in our sample, establishments report products as ASI Commodity Classification (ASICC) codes, which is a five digit product level classification system at the national level. However, from 2010-11 to 2015-16, the products are reported in NPC-MS (National Product Classification for Manufacturing sector), which is analogous to Central Product Classification (CPC) of the United Nations Statistical Division.⁵ To ensure consistent product classification across the entire sample period (2000-2015), we performed a concordance from ASICC to NPC-MS for each year of data to ensure that the product codes are in a uniform series.⁶

3.2.2 Concordance from SSI product codes to NPC-MS product codes

The main objective of our paper is to see the effect of SSI de-reservation on firms' product scope and performance. Small scale de-reservation specifically targeted products rather than firms. Having organised the product level data uniformly in NPC-MS series, our next task is to identify the set of products that are subject to de-reservation.⁷ These products are provided by the Ministry of Small and Medium Enterprises, but in SSI product codes. Since in our data set of Annual Survey of Industries (ASI), product level data is given in NPC-MS, we created a concordance between the SSI product codes and NPC-MS product codes and mapped these products to our panel of manufacturing establishments. Now we can identify the factories that make the SSI products and the year in which they are subject to de-reservation policy.

3.2.3 Sub-samples to measure the heterogeneous effects of de-reservation policy

To address the heterogeneous effect of effects of de-reservation policy on plants with different size, we divided the units into 'small' and 'large' based on the number of employees. The plants with employees less than or equal to the median employees of the full sample are considered as 'small' and plants with employees more than the median level is regarded as 'large' units. In our dataset for manufacturing enterprises, the median number of employees is 33.

Further, we have created the sub-samples for incumbent and new entrant enterprises. Incumbents are establishments that engaged in the production of reserved products before the implementation of de-reservation reforms. These establishments already possessed market presence and experience in manufacturing the reserved products. Conversely, new entrants are establishments that ventured into the product space following the de-reservation of the product. These establishments had not previously produced the reserved product and entered the market in the aftermath of de-reservation.

Other than these two categorisation, we divided the sample into new input users and others, innovators and non-innovators, and imports and non-importers. To identify new input users, we create dummy variables for newly imported inputs and newly domestically sourced inputs, following the concordance procedure outlined in the previous subsection. Plants that incorporate new inputs in their production process, whether imported or sourced domestically, are regarded as new input users. We have addressed two key considerations to eliminate potential ambiguities when identifying new inputs. First, we do not classify an input as 'new to the plant' if it was purchased in the first year of the plant's appearance in the dataset, as it may have been used in previous years before the plant became part of the dataset. Second, if an input was purchased and then discontinued in the consecutive year before being repurchased, it is not considered a 'new input to the plant' by definition, as the plant already has experience using that particular input.

Similar to the case of inputs, in determining the products that are novel to the enterprise, we have addressed the following considerations. First, if a unit introduces a product in its first year of appearance in the database, it is not regarded as a new product unless the year of appearance coincides with the incorporation year of the plant. Second, if a product is introduced and then discontinued in the consecutive year before being reintroduced, this product is not considered as a new product. We categorize importers and non-importers with a dummy variable based on their importing behavior.

3.3 Variable definition

In this study, we define the proxies for a firm's product scope as the introduction of new products and the share of sales of new products in total

sales. To measure the performance of the enterprises, we use labor productivity and sales growth. Labor productivity is calculated as the ratio of the real value of output to the number of employees. Sales growth is calculated as the logarithm of total sales in period t minus the logarithm of total sales in period $t - 1$, with sales value being deflated using the Whole sales Price Index for NIC 2 digit industries.⁸

To identify the de-reservation policy status of a unit, we develop a binary variable that takes on a value of 1 if the main product of the establishment has been de-reserved in a specific year. Once a factory has been de-reserved, it is considered as 'de-reserved' in all subsequent years. We define innovative enterprises as those that introduce a new product in the current year compared to the previous year.

We also consider other plant-specific characteristics, such as whether a plant produces more than one product, whether it is publicly listed, and plant age, size, sales, working capital, cash holdings and staff welfare expenses⁹. Table 1 provides detailed definition of the variables used in this study.

3.4 Summary statistics

In figure 1, we present an overview of share of output from reserved products in total output and share of plants producing reserved products in total number of plants. Even though, the process of de-reservation started in late 1990s, de-reservation on a large scale occurred from 2004 to 2008. We see that, until 2003, output share from reserved products was increasing and there was a commensurate increase in the number of plants that produce these SSI products. The increase in the number of plants could be attributed to new entry of firms into the reserved product space. However, once the de-reservation started, we see a reduction in output and exit of firms from this product space. Reduction in the share of output is faster than the reduction in number of plants producing these products.

3.4.1 Small vs large units

From the summary statistics, we in general observe that small firms have slightly higher likelihood to introduce new products with respect to their larger counterparts from table 2. This might be mainly because of the fact that larger firms focus more on the new processes especially backed by R&D whereas smaller

Table 1: Definition of Variable

Variable	Definition
New Product	Dummy variable takes the value 1 if a plant has introduced a new product to the unit in year t and 0 otherwise

New Product Share	Ratio of sales of new products in total sales of the establishment
Labour Productivity	Log value of real output divided by Number of employees
Sales Growth	Log value of real gross sales in year t minus Log value of real gross sales in year $t - 1$
De-reservation status	Dummy variable takes the value 1 if a plant is subject to de- policy in year t and 0 otherwise
Multi Product dummy	Dummy variable takes the value 1 if a plant has more than one product in it's portfolio in year t and 0 otherwise
Private Ownership dummy	Dummy variables takes the value 1 if the unit is privately owned and 0 if it is publicly listed
Plant Age	Log value of the number of years since the year of beginning of production
Factory Size	Log value of the number of employees in year t
Working Capital	Real working capital in year t in million INR
Wages	Real age and salaries in year t in million INR
Welfare Expenses	Real staff Welfare Expenses in year t in million INR
Cash holdings	Real Cash-in-hand in year t in million INR
Sales	Real gross sales in year t in million INR
New Input user	Dummy variable takes the value 1 if a plant has used a new input to the plant in year t and 0 otherwise
Importer Dummy	Dummy variable takes the value 1 if a plant has imported in year t and 0 otherwise
Incumbent Dummy	Dummy variable takes the value 1 if a plant has been producing a re- served product before de-reservation and 0 otherwise
New entrant Dummy	Dummy variable takes the value 1 if a plant has entered into the product space after de-reservation and 0 otherwise
Small unit Dummy	Dummy variable takes the value 1 if a plant has less than or equal to 33 employees and 0 otherwise

units often thrive to introduce new products. Empirical evidences also show that larger firms devote a higher proportion of their research and development (R&D) expenditure on new process development than smaller firms even though process and product R&D spending rise less than in proportion to firm size (Fritsch and Meschede, 2001). In general, for multi product units it is relatively easier to introduce a new product through incremental innovations than that of a single product firm. In our sample there is no remarkable difference between the proportion of units with multi products between small and large units.

As argued by previous studies on India on the productivity differences between formal large and informal small firms including Bloom et al. (2013); Goldar and Kumari (2003); Goldar (2015) among others, in our sample also, we observe larger establishments have higher labour productivity than small units. The sales growth differences could also be read in this line as Aw (2002) argue that firms grow more as they are more productive.

De-reservation status variable implies if the establishments are subject to policy change. If the variable takes the value 1 year t , it means that the unit is subject to de-reservation in that year. Once a unit got de-reserved, it is treated as de-reserved in the subsequent years. The threshold fixed for the exclusive right to produce those products are capital based, not labour based. This threshold gets changed over time. Therefore, in our sample, among the SSI plants, there are many units that are small by product reservation standards but larger in terms of number of employees.

Not surprisingly, a greater proportion of large units are publicly listed (17%) where as only 4% of smaller units are listed in the stock market. Further, small units are 2 years younger than their larger counterparts. Needless to say, plants with 33 employees or more have significantly higher working capital, cash holdings, wage bills, and staff welfare expenses and sales turnover on average.

3.4.2 Innovators vs non-innovators and incumbents vs new entrants

From table 3, we observe that two-third of the sales of innovating units are contributed by sales of new products. However for incumbent firms and new entrants, there is no marked differences. Incumbents are those units that were in the SSI product market over time must be specialising in those products especially before the de-reservation. For new entrants, although they have entered into the SSI product space after the de-reservation of these products, new products including these SSI products contribute only one-quarter of their sales portfolio. Before entering this product space, most of these units were producing other products other than SSI products¹⁰.

As indicated by earlier studies including Coad et al. (2020, 2016); Cassiman and Golovko (2011), innovative units have relatively higher sales growth compared to non-innovative units. Moreover, innovators are more productive than non-innovators. In our sample 51% of innovative firms are subject to de-reservation policy where as it is only half of that in non-innovative units. No wonder, in all other variables we have looked into, including sales, plant size, working capital, wage bills, cash holdings and staff welfare expenses innovative units are on average larger than non-innovative units. Further innovative firms are slightly older than non-innovative firms.

As in the case of innovators and non-innovators, there are remarkable differences between incumbents and new entrants especially in sales, sales

growth, working capital, wages, welfare expenses and cash holdings. New entrants are five years on average younger than the incumbent firms.

3.4.3 New input users, importers and non-importers

Enterprises are heterogeneous in the use of new inputs. Typically firms that use new inputs might have more exposure to suppliers and clients than the ones that do not use new inputs. From table 4, we see that, establishments that use new inputs are larger in general and particularly they are more innovative both in terms of introduction of new products and share of new products in sales. Further, there are more multi product plants that use new inputs compared to the ones that do not use new inputs in production. What we have observed in the case of size consistently hold true for both working capital, sales, staff welfare expenses, wages and cash holdings. Notably, we see that new input users are at least 4 years older than other plants which implies more experience in the market enable them to find better and quality inputs and new new suppliers and also they are more productive.

Consistent with both theory and evidence (Vogel and Wagner, 2010; Foster-McGregor et al., 2014; Abreha, 2019), importing plants are typically larger than the non-importing ones. Moreover, in line with the previous studies of India, for example Nataraj (2011), smaller firms have substantially lower access to international market compared to larger ones even after the large scale trade reforms. This is clearly evident from our data set that the use of imported inputs in production by small plants is substantially lower as compared to large ones (see table 2). From table 4, it is clear that as in the case of new input users, importing plants in general have higher sales, working capital, wage bills, cash holdings and staff welfare expenses.

Figure 1: Share of output from reserved products in total output and share of plants producing reserved products out of total plants

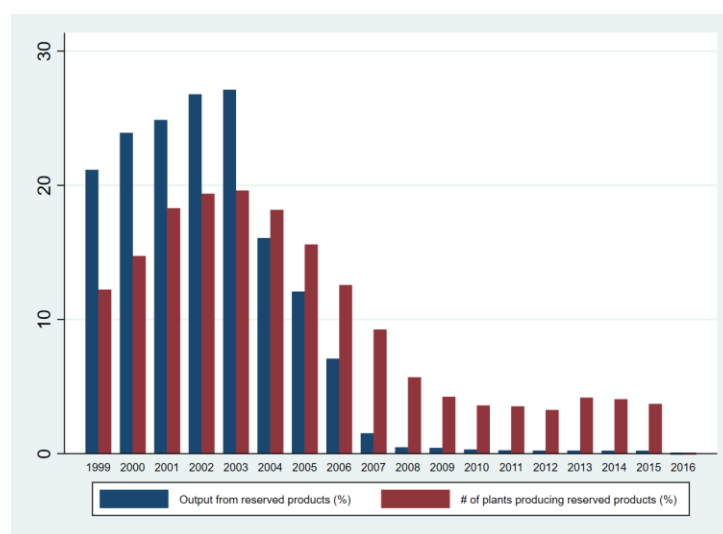


Table 2: **Size-wise comparative summary statistics**

Full Sample Variable	Small units		Large units		Mean	Std. Dev
	Mean	Std. Dev	Mean	Std. Dev		
New Product dummy	0.22	0.41	0.24	0.43	0.21	0.41
New Product Share	0.16	0.35	0.19	0.38	0.14	0.33
Labour Productivity	5.89	0.67	5.79	0.63	5.98	0.69
Sales Growth	0.06	0.75	0.01	0.84	0.09	0.70
De-reservation status	0.30	0.46	0.32	0.46	0.29	0.45
Multi Product dummy	0.25	0.43	0.25	0.43	0.25	0.44
Ownership dummy	0.12	0.32	0.04	0.19	0.17	0.38
Plant Age	17.62	16.20	16.55	13.92	18.66	18.06
Factory Size	1.61	0.68	1.06	0.32	2.17	0.45
Working Capital	63.48	2486.04	4.30	112.99	121.68	3498.26
Wages	24.85	198.93	1.01	4.48	48.81	279.60
Welfare Expenses	2.05	26.65	0.05	0.80	3.75	36.14
Cash holdings	20.48	611.50	1.37	74.70	39.30	857.89
Sales	717.16	13604.98	29.47	392.38	1348.05	18813.05
Importer dummy	0.22	0.42	0.08	0.28	0.32	0.47

Note: Small units are the ones with less than/equal to median of number of employees in our sample. Median of number of employees is 33.

Table 3: Comparative summary statistics: innovators vs non-innovators and incumbents vs new entrants

Variable	Innovative Units		Non-innovative Units		Incumbent Units		New-entrant Units	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
New Product dummy					0.38	0.48	0.35	0.48
New Product Share	0.74	0.38			0.25	0.40	0.26	0.42
Labour productivity	6.03	0.62	5.82	0.68	5.80	0.59	5.96	0.63
Sales growth	0.10	0.79	0.04	0.72	0.05	0.60	0.09	0.73
De-reservation status	0.51	0.50	0.24	0.43	0.63	0.48	0.91	0.28
Multi-product dummy	0.53	0.50	0.17	0.38	0.41	0.49	0.40	0.49
Ownership dummy	0.19	0.39	0.10	0.30	0.15	0.36	0.13	0.33
Plant age	19.23	15.70	17.02	16.34	21.65	16.56	16.41	13.84
Factory size	1.75	0.68	1.56	0.67	1.67	0.67	1.70	0.68
Working capital	113.19	2811.89	44.45	2349.05	32.24	1625.37	108.77	3420.07
Wages	39.50	273.53	19.22	160.93	24.10	196.90	39.54	299.68
Welfare expenses	3.73	34.79	1.47	23.19	2.37	29.45	3.79	44.61
Cash holdings	34.06	934.27	15.25	426.12	11.97	200.92	31.26	877.20
Sales	1155.14	21441.72	511.48	7482.40	542.20	7531.55	1208.03	23347.36

Table 4: **Comparative summary statistics: new input users and importers**

Variable	ew Input Users		New Input Users		nportingUnits		n-Importing Units	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
New Product dummy	0.47	0.50	0.06	0.24	0.40	0.49	0.19	0.39
New Product Share	0.35	0.45	0.04	0.20	0.25	0.40	0.15	0.34
Labour productivity	5.95	0.64	5.82	0.69	6.29	0.53	5.79	0.66
Sales growth	0.10	0.73	-0.01	0.77	0.11	0.63	0.05	0.79
De-reservation status	0.41	0.49	0.23	0.42	0.44	0.50	0.28	0.45
Multi-product dummy	0.38	0.49	0.17	0.38	0.50	0.50	0.21	0.41
Ownership dummy	0.19	0.39	0.07	0.26	0.37	0.48	0.08	0.27
Plant age	19.54	16.36	15.89	15.85	18.86	16.50	17.38	16.13
Factory size	1.74	0.68	1.49	0.65	2.27	0.59	1.48	0.62
Working capital	91.69	2693.60	36.92	2273.47	272.02	4947.29	21.51	1577.22
Wages	14.28	90.35	0.92	7.48	102.01	460.48	9.26	57.07
Welfare expenses	1.17	12.40	0.08	1.30	10.28	65.08	0.55	7.29
Cash holdings	11.21	176.17	0.49	23.47	88.96	1328.21	6.66	303.58
Sales	248.28	2169.15	8.81	107.80	2865.29	30779.43	207.16	1662.78

4 Methodology and Econometric Specification

In this section, we specify the empirical model to measure the effect of SSI de-reservation on establishment level outcomes - product scope and performance and how the effects varies with different firm characteristics. Difference-in-Difference (DID) is one of the most popular research design used to evaluate the causal effects of policy interventions. Deviating from the canonical DID setup, in many cases, we have more than two time periods and variation in treatment timing. and thereby it becomes difficult to identify, estimate, and infer treatment effect parameters. However there is a very active recent literature relaxing the assumption of 2 periods and a common treatment date

and focus on what if there are multiple periods and units adopt treatment at different time points (Goodman-Bacon, 2021; Sun and Abraham, 2021; Callaway and Sant'Anna, 2021). These studies maintain the ingredients of parallel trend and many clusters.

The policy that we address in this paper is similar to the above case. Product de-reservation policy has been carried out phase by phase from the late 1990s for a decade. Each year different set of products got de-reserved and therefore the year at which establishments got subject to the policy differs. Almost 70% of the SSI products producing units got de-reserved between 2003 and 2007. Therefore, in our dataset a firm has several years before and after the policy intervention since the time span of our study is from 2000 to 2016. In this case, we estimate the treatment effect parameters using Difference-in-Difference with multiple treatment periods and variation in the timing of treatment. We use the methodology developed by Callaway and Sant'Anna (2021) to evaluate the effect of de-reservation policy.

To begin with, we note whether an enterprise is ever observed making any product that was ever in the reserved list, irrespective of the fact that it got de-reserved later and we refer these products as SSI products. Once we have identified the establishments that makes at least one SSI product, we look into the year at which that product got de-reserved. we created a dummy variable called Dereservation status that goes from 0 to 1 when the product manufactured by an enterprises gets de-reserved. The baseline DID model is as below.

$$Y_{it} = \alpha + \beta \text{Dereservation status}_i + \gamma \text{Post}_t + \delta (\text{Dereservation status}_i \bullet \text{Post}_t) + \theta X_{it} + \epsilon_{it} \quad (1)$$

This equation models the outcome (Y_{it}) for unit i at time t as a function of Dereservation status, time period (Post_t), and their interaction. The coefficient δ represents the average treatment effect on the treated (ATT) and θ represents the coefficient of the covariates used in the DID equation.

Our model starts with four basic conditions as postulated by Callaway and Sant'Anna (2021). Firstly, there is no treatment in the first year. This assumption is set to have at least one pre-treatment year for the units. Secondly, the units got treatment in all the years are excluded from the model. Thirdly, causal effect parameters are identified in a staggered manner. It means that once a unit got 'de-reserved', it is considered as 'de-reserved' in all the subsequent years. And lastly, we assume that the parallel trend assumption holds potentially only after conditioning on observed covariates. The covariates that we have considered are plant age, plant size, ownership dummy, multi-product dummy, working capital, wages, staff welfare expenses, cash holdings and sales. Here is the equation that accounts for multiple time periods in DID:

$$Y_{it} = \alpha + \beta \text{Dereservation status}_i + \gamma_1 \text{Post}_{t1} + \gamma_2 \text{Post}_{t2} + \dots + \gamma_T \text{Post}_{tT} + \delta(\text{Dereservation status}_i \cdot \text{Post}_{tt}) + \epsilon_{it} \quad (2)$$

In this equation, T time periods exist ($t_1, t_2, \dots, t_T$), each with its own coefficient (γ), allowing for the potential of varying treatment effects over time. The δ coefficient signifies the average treatment effect on the treated (ATT), now contingent on the specific time period under examination.

Based on the assumption of the staggered treatment adoption in the model proposed by Callaway and Sant'Anna (2021), we define G as the time period when a unit first become de-reserved. For all units that eventually participate in the treatment, G defines which 'group' they belong to. The units that do not participate are 'never treated' and we use this as our comparison group. We define G_g to be a binary variable that is equal to 1 if a unit got first treated in time g.

Our outcome variables are introduction of new product, share of new product sales in total sales, labour productivity and sales growth. To identify the heterogeneous effects, we have implemented the DID with multiple time periods for different sub-samples. These sub samples include small and large firms, incumbents and new entrants, innovators and non-innovators, new input users and others and importers and non- importers.

As in the case of other doubly robust methods, for example Słoczyński and Wooldridge (2018), following Callaway and Sant'Anna (2021) we have to specify two models: the treatment and the outcome model. The treatment model is the regression model that relates the treatment status to any observed covariates. The goal of the treatment model is to estimate the propensity score, which is the conditional probability of receiving treatment given the observed covariates. This can be used to balance the distribution of covariates between treated and untreated units, which can help to reduce bias in estimating treatment effects. It is important to choose a set of covariates that are predictive of treatment assignment, as well as a functional form for the relationship between these covariates and treatment. The outcome model is the regression model that relates the outcome variable to the treatment status and any other covariates. It is important to choose a functional form for this model that accurately captures the relationship between the outcome and treatment, as well as any potential confounding factors that may affect both. We use weighted least squares for the outcome model and inverse probability tilting for the treatment model. After controlling for the potential covariates, our model satisfy the pre-trend assumption which implies that both treatment group and comparison group are comparable before the treatment begins. The equation that accounts for multiple time periods and group fixed effects is:

$$Y_{it} = \alpha + \alpha_g + \beta \text{Dereservation status}_i + \gamma_1 \text{Post}_{t1} + \gamma_2 \text{Post}_{t2} + \dots + \gamma_T \text{Post}_{tT} + \delta(\text{Dereservation status}_i \cdot \text{Post}_{tt}) + \epsilon_{it} \quad (3)$$

In this equation, α_g represents a group fixed effect, which captures any time-invariant differences between groups that may affect the outcome. The other coefficients have the same interpretation as in the previous equation.

5 Results

5.1 Effects of de-reservation on plant level outcomes: full sample

Table 5 shows that the implementation of product de-reservation has had a positive effect on the overall level of new product introductions. This outcome can be attributed to two main factors. Firstly, the implementation of the product de-reservation policy prompted small-scale plants to seek out new products due to increased competition from other firms. Secondly, many firms that were previously unable to produce SSI products due to their non-SSI status are now allowed to do so, contributing to the overall likelihood of new product introductions.

Prior to the implementation of this policy, certain products were reserved exclusively for production by small-scale units in order to promote their growth and development. However, this also limited the entry of larger firms into these product spaces. The abolition of the reserved items removed these restrictions and opened up these products to larger firms, with the aim of promoting greater competition and efficiency. This has led to overall sales growth, as evidenced by the results in Table 5. These findings suggest that further investigation into the heterogeneity of these effects for different types of plants is warranted, as detailed in the following tables.

5.2 Heterogeneous effects of de-reservation on plants with different size

It is reasonable to assume that the product de-reservation policy might have heterogeneous effects on plants with different sizes. The firms that entered into the product space after the de-reservation were not the ones constrained by size threshold, while some of the incumbent firms expanded their size and others tried to survive in the market despite their capital constraints.

To investigate this, we looked at the median level of employees (which is 33) and classified plants into two groups: those with number of employees less than or equal to the median, and those with number of employees greater than the median. Results in Table 6 show that the SSI product de-reservation policy had no/negligible effect on plants with an employee size of 33 or less except a significant effect on the likelihood of introducing new products at a 10 percent level. However, for large plant units, the effectiveness of the policy is more clear and evident for the introduction of new products, labour productivity and sales growth. We believe that the reason for the introduction of new products might be different for small and large plants. For plants with less than median employees, it must be the cut throat competition from other plants of large size by labour standards especially the new entrant plants that entered into the

product space after de-reservation. On the other hand, much of the larger plants by labour standard were waiting for the removal of SSI reservation, so that they could expand their capital base which is required to move towards other product lines. Product introduction alone does not tell anything about the performance of these products. We see that product de-reservation did not have significant effect over the share of new product sales. This holds true for sales growth as well as labour productivity. As Garcia-Santana and Pijoan-Mas (2014) argues, this productivity gains of lifting small scale reservation are partly due to better allocation of production factors and partly due to capital deepening. Capital deepening is more associated with embodied technology transfers especially through import of new intermediate inputs and these activities are mostly undertaken by plants with a larger size.

5.3 Heterogeneous effects of de-reservation on innovators and non innovators

Product innovation refers to one of the main form of innovative efforts, benefiting the innovating firm in enhancing market share and entry into new markets (Pavitt, 1998), though introduction of new products does not inform anything about its sustainability in the market. As previous studies among others (Teece et al., 1994; Nelson and Winter, 1982; Dosi et al., 2017) note, successful accomplishment of product innovation depends on and at the same time constrained by the existing stock of knowledge embedded at the organisational level. Enterprises could be heterogeneous in these knowledge stock and the resulting product breadth which may coevolve with size. This could have an impact on plant level outcomes related to performance. This observation seems more feasible from our subsequent results which signifies that de-reservation policy has a positive and significant effect on the performance of plants that are innovators.

Table 7 examines the effect of SSI product de-reservation on labour productivity and sales growth. As with many firm-specific policies, the firms that benefited from the reforms were found to be innovative firms. This result holds true for both labor productivity and sales growth. For non-innovative firms, we did not find any statistically significant effect of the product de-reservation policy.

Table 5: Effects of product de-reservation on product scope and performance

	(1) New product	(2) New product share in sales	(3) Labour productivity	(4) Sales. Gr.
Full Sample				
ATT	0.0325*** (0.0106)	0.0098 (0.0085)	0.0126* (0.0070)	0.0402*** (0.0135)
ATT Pre Average	-0.0128 (0.0203)	-0.0103 (0.0236)	0.0205 (0.0076)	0.0556** (0.0241)
ATT Post Average	0.0290** (0.0137)	0.0043 (0.0106)	0.0117 (0.0101)	0.0429*** (0.0160)
Number of observations	90735	90735	84952	85192
Pre Trend p value	0.2225	0.5752	0.2408	0.0776

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Treatment model: Inverse probability tilting and Outcome model:
Weighted least squares

Table 6: Heterogeneous effects of product de-reservation on product scope and performance: Small vs large

	(1) New product	(2) New product share in sales	(3) Labour productivity	(4) Sales. Gr.
Small units				
ATT	0.0428* (0.0230)	0.0082 (0.0189)	-0.0220 (0.0151)	0.0103 (0.0291)
ATT Pre Average	0.0062 (0.0278)	0.0123 (0.0191)	0.0095 (0.0134)	0.0025 (0.0486)
ATT Post Average	0.0166 (0.0340)	0.0090 (0.0276)	-0.0393 (0.0216)	-0.0026 (0.0339)
Number of observations	19625	19625	18030	18053
Pre Trend p value	0.7358	0.8964	0.3417	0.5257
Large units				
ATT	0.0260**	0.0057	0.0160**	0.0560 ***

ATT Pre Average	(0.0127) -0.0173	(0.0100) -0.0090	(0.0075) 0.0247***	(0.0148) 0.1063***
ATT Post Average	(0.0232) 0.0236	(0.0262) -0.0027	(0.0094) 0.0198*	(0.0290) 0.0694***
Number of observations	(0.0170) 65199	(0.0128) 65199	(0.0108) 61855	(0.0172) 61968
Pre Trend p value	0.0561	0.0546	0.0817	0.0643

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Treatment model: Inverse probability tilting and Outcome model: Weighted least squares

Table 7: Effect of product de-reservation on performance: innovative vs non-innovative plants

Innovative Units	Non-Innovative			
Units	Labour productivity	Sales. Gr.	Labour productivity	Sales. Gr.
ATT	0.0237** (0.0102)	0.0698*** (0.0203)	0.0067 (0.0092)	0.0165 (0.0180)
ATT Pre Average	0.0291*** (0.0110)	0.0329 (0.0336)	0.0176 (0.0148)	0.1041** (0.0462)
ATT Post Average	0.0070 (0.0207)	0.0847*** (0.0295)	0.0066 (0.0141)	0.0221 (0.0236)
Number of observations	41375	41523	60131	60278
Pre Trend p value	0.0686	0.4535	0.2801	0.0868

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Treatment model: Inverse probability tilting and Outcome model: Weighted least squares

5.4 Heterogeneous effects of de-reservation on incumbents and new entrants

Table 8 also shows that the effects of the product de-reservation policy were not uniform across plants. Specifically, we examine the cases of incumbent plants and new entrants. Incumbents are those producing the reserved product prior to the reforms, while new entrants are those units that moved

into the product space after the product was de-reserved. Our results indicate that the policy was helpful for increased sales growth for the incumbent firms, but had no significant impact in terms of product scope and productivity. This result is in line with [Singh \(2017\)](#) that as a result of the product de-reservation, incumbent firms have reduced the price by 8.6 percent overall and this might have lead to increased sales growth. On the other hand, the policy had a positive impact on product scope and productivity for new entrants. One possible explanation for this difference is that product scope and labor productivity could be more closely linked to technological and organizational capabilities, while sales growth might be more related to scale of operations. Many of the incumbent firms were previously constrained by the capital threshold and could expand their size after the policy reforms, whereas new entrants might be embedded with greater technological and organizational capabilities, which is reflected in their product scope and productivity.

5.5 Heterogeneous effects of de-reservation on plants that use new inputs and not

From table 9, we present the effects of de-reservation and how it varies between the plants that employ new inputs in production and the ones that do not use them. The use of new inputs is considered for both imported inputs and domestic inputs. The reason to look at the heterogeneous effects of input use on de-reservation is primarily due to the fact that product reservation policy has mainly targeted products and the product scope of plants is also expected to vary based on the new inputs use. The major trade reforms in India in the beginning of 1990s have not only made better and cheaper inputs available but also new inputs which were previously unavailable got available. Goldberg et al. (2010a) provides evidences for the fact that two-thirds of the intermediate import growth after liberalisation occurred in products that were not imported prior to the reforms along with an explosion in the number of imported inputs.

We observe that there are differences in the effect of product de-reservation policy for the plants that use

Table 8: Heterogeneous effects of product de-reservation on product scope and performance: Incumbents vs new entrants

	(1) New product	(2) New product share in sales	(3) Labour productivity	(3) Sales. Gr.
incumbent units	-0.0073	-0.0146	0.0042	0.0430***
ATT	(0.0118)	(0.0094)	(0.0073)	(0.0137)
ATT Pre Average	-0.0180	-0.0095	0.0183	0.0547**
	(0.0202)	(0.0237)	(0.0077)	(0.0250)
ATT Post Average	-0.0246	-0.0259	0.0059	0.0496***
	(0.0171)	(0.0132)	(0.0124)	(0.0184)
Number of observations	82253	82253	76239	76452
Pre Trend p value	0.4041	0.7063	0.0671	0.3187
New entrants				
ATT	0.1277***	0.0700***	0.0323 **	0.0370
	(0.0198)	(0.0163)	(0.0126)	(0.0282)
ATT Pre Average	0.0749	0.0033	0.0369	0.0957
	(0.0886)	(0.0784)	(0.0368)	(0.1125)
ATT Post Average	0.1226***	0.0634***	0.0262*	0.0366
	(0.0198)	(0.0175)	(0.0148)	(0.0294)
Number of observations	60674	60674	56601	56746
Pre Trend p value	0.0734	0.0650	0.1389	0.0840

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Treatment model: Inverse probability tilting and Outcome model:
Weighted least squares

Table 9: Heterogeneous effects of product de-reservation on product scope and performance: New input users and others

	(1) New product	(2) New product share in sales	(3) Labour productivity	(4) Sales. Gr.
New inputs				
users	0.0362**	0.0193	0.0067	0.0329*
ATT	(0.0152)	(0.0119)	(0.0093)	(0.0191)
ATT Pre	-0.0449	-0.0279	0.0205	0.0070
Average	(0.0319)	(0.0297)	(0.0086)	(0.0255)
ATT Post	0.0744	0.0701***	-0.0020	0.0236
Average	(0.0275)	(0.0221)	(0.0138)	(0.0340)
Number of observations	50756	50756	50439	50485
Pre Trend p value	0.1535	0.1614	0.6022	0.0560
Without new				
inputs				
ATT	0.0270*	0.0142	0.0323	0.0326
	(0.0143)	(0.0119)	(0.0126)	(0.0201)
ATT Pre	-0.0276	-0.0219	0.0369	0.0605**
Average	(0.0214)	(0.0220)	(0.0368)	(0.0299)
ATT Post	0.0298	0.0093	0.0262*	0.0525**
Average	(0.0181)	(0.0149)	(0.0148)	(0.0246)
Number of observations	66259	66259	61328	61526
Pre Trend p value	0.3181	0.1658	0.0588	0.0553

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Treatment model: Inverse probability tilting and Outcome model:
Weighted least squares

Table 10: Heterogeneous effects of product de-reservation on product scope and performance: Importers vs non-importers

	(1) New product	(2) New product share in sales	(3) Labour productivity	(4) Sales. Gr.
Importers				
ATT	0.0347** (0.0164)	0.0047 (0.0128)	0.0038 (0.0098)	0.0337* (0.0198)
ATT Pre Average	0.0239 (0.0324)	0.0040 (0.0177)	0.0024 (0.0136)	-0.0075 (0.0487)
ATT Post Average	0.0415 (0.0200)	0.0047 (0.0152)	0.0013 (.0130)	0.0361 (0.0223)
Number of observations	37754	37754	35889	35944
Pre Trend p value	0.1085	0.4547	0.0563	0.1168
Non-importers				
ATT	0.0392*** (0.0141)	0.0198* (0.0116)	0.0123 (0.0098)	0.0456** (0.0191)
ATT Pre Average	-0.0567** (0.0230)	-0.0440 (0.0266)	0.0255*** (0.0083)	0.0863*** (0.0262)
ATT Post Average	0.0212 (0.0186)	0.0085 (0.0155)	0.0130 (0.0148)	0.0511** (0.0240)
Number of observations	51701	51701	47882	48059
Pre Trend p value	0.4097	0.4034	0.0599	0.0532

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Treatment model: Inverse probability tilting and Outcome model:
Weighted least squares

References

- ABREHA, K. G. (2019): "Importing and firm productivity in Ethiopian manufacturing," *The World Bank Economic Review*, 33, 772–792.
- AGHION, P., R. BURGESS, S. J. REDDING, AND F. ZILIBOTTI (2008): "The unequal effects of liberalization: Evidence from dismantling the License Raj in India," *American Economic Review*, 98, 1397–1412.
- AMITI, M. AND J. KONINGS (2007): "Trade liberalization, intermediate inputs, and productivity: Evidence from Indonesia," *American Economic Review*, 97, 1611–1638.
- ARBELO, A., M. ARBELO-PE´REZ, AND P. PE´REZ-GO´MEZ (2022): "Are SMEs less efficient? A Bayesian approach to addressing heterogeneity across firms," *Small Business Economics*, 58, 1915–1929.
- AW, B.-Y. (2002): "Productivity dynamics of small and medium enterprises in Taiwan," *Small Business Economics*, 18, 69–84.
- BARNEY, J. (1991): "Firm resources and sustained competitive advantage," *Journal of Management*, 17, 99–120.
- BAS, M. AND V. STRAUSS-KAHN (2014): "Does importing more inputs raise exports? Firm-level evidence from France," *Review of World Economics*, 150, 241–275.
- BENTO, P. AND D. RESTUCCIA (2017): "Misallocation, establishment size, and productivity," *American Economic Journal: Macroeconomics*, 9, 267–303.
- BERTRAND, M. AND F. KRAMARZ (2002): "Does entry regulation hinder job creation? Evidence from the French retail industry," *The Quarterly Journal of Economics*, 117, 1369–1413.
- BIGSTEN, A. AND M. GEBREEYESUS (2007): "The small, the young, and the productive: Determinants of manufacturing firm growth in Ethiopia," *Economic Development and Cultural Change*, 55, 813–840.
- BLOOM, N., B. EIFERT, A. MAHAJAN, D. MCKENZIE, AND J. ROBERTS (2013): "Does management matter? Evidence from India," *The Quarterly Journal of Economics*, 128, 1–51.
- CALLAWAY, B. AND P. HSANT'ANNA (2021): "Difference-in-differences with multiple time periods," *Journal of Econometrics*, 225, 200–230.
- CASSIMAN, B. AND E. GOLOVKO (2011): "Innovation and internationalization through exports," *Journal of International Business Studies*, 42, 56–75.
- CASTELLANI, D. AND C. FASSIO (2019): "From new imported inputs to new exported products. Firm-level evidence from Sweden," *Research Policy*, 48, 322–338.
- CHANDLER, V. (2012): "The economic impact of the Canada small business financing program," *Small Business Economics*, 39, 253–264.
- COAD, A., N. MATHEW, AND E. PUGLIESE (2020): "What's good for the goose ain't good for the gander: heterogeneous innovation capabilities and the performance effects of R&D," *Industrial and Corporate Change*, 29, 621–644.

- COAD, A., A. SEGARRA, AND M. TERUEL (2016): "Innovation and firm growth: does firm age play a role?" *Research Policy*, 45, 387–400.
- DEBROY, B., A. DUBEY, L. BHANDARI, AND M. BORDOLOI (2006): "Small Sector in India: Status, Growth and De-Reservation," Rajiv Gandhi Institute for Contemporary Studies.
- DOSI, G., M. GRAZZI, AND D. MOSCHELLA (2017): "What do firms know? What do they produce? A new look at the relationship between patenting profiles and patterns of product diversification," *Small Business Economics*, 48, 413–429.
- DOSI, G., N. MATHEW, AND E. PUGLIESE (2020): "What a firm produces matters: Processes of diversification, coherence and performances of Indian manufacturing firms," *Research Policy*, 104152.
- FOSTER-MCGREGOR, N., A. ISAKSSON, AND F. KAULICH (2014): "Learning-by-exporting versus self-selection: New evidence for 19 sub-Saharan African countries," *Economics Letters*, 125, 212–214.
- FRITSCH, M. AND M. MESCHKE (2001): "Product innovation, process innovation, and size," *Review of Industrial Organization*, 19, 335–350.
- GARCIA-SANTANA, M. AND J. PIJOAN-MAS (2014): "The reservation laws in India and the misallocation of production factors," *Journal of Monetary Economics*, 66, 193–209.
- GARICANO, L., C. LELARGE, AND J. VAN REENEN (2016): "Firm size distortions and the productivity distribution: Evidence from France," *American Economic Review*, 106, 3439–79.
- GIFFORD, S. (1993): "Heterogeneous ability, career choice and firm size," *Small Business Economics*, 5, 249–259.
- GOLDAR, B. (2015): "Productivity in Indian manufacturing (1999–2011): accounting for imported materials input," *Economic and Political Weekly*, 104–111.
- GOLDAR, B. AND A. KUMARI (2003): "Import liberalization and productivity growth in Indian manufacturing industries in the 1990s," *The Developing Economies*, 41, 436–60.
- GOLDBERG, P. K., A. K. KHANDELWAL, N. PAVCNIK, AND P. TOPALOVA (2009): "Trade liberalization and new imported inputs," *American Economic Review*, 99, 494–500.
- — — (2010a): "Imported intermediate inputs and domestic product growth: Evidence from India," *The Quarterly Journal of Economics*, 125, 1727–1767.
- — — (2010b): "Multiproduct firms and product turnover in the developing world: Evidence from India," *The Review of Economics and Statistics*, 92, 1042–1049.
- GOODMAN-BACON, A. (2021): "Difference-in-differences with variation in treatment timing," *Journal of Econometrics*, 225, 254–277.
- GUNER, N., G. VENTURA, AND Y. XU (2008): "Macroeconomic implications of size-dependent policies," *Review of Economic Dynamics*, 11, 721–744.
- HALPERN, L., M. KOREN, AND A. SZEIDL (2015): "Imported inputs and productivity," *American Economic Review*, 105, 3660–3703.

- HALTIWANGER, J., R. S. JARMIN, AND J. MIRANDA (2013): "Who creates jobs? Small versus large versus young," *Review of Economics and Statistics*, 95, 347–361.
- HSIEH, C.-T. AND P. J. KLENOW (2009): "Misallocation and manufacturing TFP in China and India," *The Quarterly Journal of Economics*, 124, 1403–1448.
- HUSSAIN, A. (1997): "Report of the Expert Committee on Small Enterprises," Tech. rep., Department of Small Scale Industries and Business Enterprises, New Delhi.
- LEWIS, W. W. (2005): "The power of productivity," in *The Power of Productivity*, University of Chicago Press.
- MARTIN, L. A., S. NATARAJ, AND A. E. HARRISON (2017): "In with the big, out with the small: Removing small-scale reservations in India," *American Economic Review*, 107, 354–86.
- MEAD, D. C. AND C. LIEDHOLM (1998): "The dynamics of micro and small enterprises in developing countries," *World Development*, 26, 61–74.
- MELITZ, M. J. (2003): "The impact of trade on intra-industry reallocations and aggregate industry productivity," *Econometrica*, 71, 1695–1725.
- MELITZ, M. J. AND G. I. OTTAVIANO (2008): "Market size, trade, and productivity," *The Review of Economic Studies*, 75, 295–316.
- MOHAN, R. (2002): "Small Scale Industry Policy in India: A Critical Evaluation," in *Economic Policy Reforms and the Indian Economy*, ed. by A. O. Krueger, Chicago University Press, 213–302.
- MORRIS, S., R. BASANT, K. DAS, K. RAMACHANDRAN, AND A. KOSHY (2001): *The growth and transformation of small firms in India*, Oxford University Press.
- NATARAJ, S. (2011): "The impact of trade liberalization on productivity: Evidence from India's formal and informal manufacturing sectors," *Journal of International Economics*, 85, 292–301.
- NELSON, R. R. AND S. G. WINTER (1982): *An evolutionary theory of economic change*, Harvard University Press.
- NICHTER, S. AND L. GOLDMARK (2009): "Small firm growth in developing countries," *World Development*, 37, 1453–1464.
- PAN, L. AND Y. WANG (2020): "Competition among large and heterogeneous small firms," *Economics Letters*, 196, 109604.
- PANAGARIYA, A. (2008): *India: The emerging giant*, Oxford University Press.
- PAVITT, K. (1998): "Technologies, products and organization in the innovating firm: what Adam Smith tells us and Joseph Schumpeter doesn't," *Industrial and Corporate Change*, 7, 433–452.
- PETERAF, M. A. (1993): "The cornerstones of competitive advantage: a resource-based view," *Strategic Management Journal*, 14, 179–191.
- RESTUCCIA, D. AND R. ROGERSON (2008): "Policy distortions and aggregate productivity with heterogeneous establishments," *Review of Economic Dynamics*, 11, 707–720.
- ROBSON, P. J. AND B. A. OBENG (2008): "The barriers to growth in Ghana," *Small Business Economics*, 30, 385–403.

- ROTEMBERG, M. (2019): "Equilibrium effects of firm subsidies," *American Economic Review*, 109, 3475– 3513.
- SEN, A. AND P. RAY (2015): "The Ascent and Decline of Reservation in Indian Small Scale Industries: Evolution of the Policy Environment," .
- SINGH, M. (2017): "Financial constraints and trade credit as a strategic tool: Evidence from small-scale reservation reforms in India," in 28th Annual Conference on Financial Economics and Accounting, Fox School of Business.
- S-LOCZYN'SKI, T. AND J. M. WOOLDRIDGE (2018): "A general double robustness result for estimating average treatment effects," *Econometric Theory*, 34, 112–133.
- SUN, L. AND S. ABRAHAM (2021): "Estimating dynamic treatment effects in event studies with heterogeneous treatment effects," *Journal of Econometrics*, 225, 175–199.
- TEECE, D. J., R. RUMELT, G. DOSI, AND S. WINTER (1994): "Understanding corporate coherence: Theory and evidence," *Journal of Economic Behavior & Organization*, 23, 1–30. TEWARI, I. AND J.
- WILDE (2019): "Product Scope and Productivity: Evidence from India's Product Reservation Policy," *Southern Economic Journal*, 86, 339–362.
- VAN BIESEBROECK, J. (2005): "Firm size matters: Growth and productivity growth in African manufacturing," *Economic Development and Cultural Change*, 53, 545–583.
- VELAYUDHAN, S. K. (2004): "Market justification for policy on small enterprise development," *Small Business Economics*, 22, 111–120.
- VOGEL, A. AND J. WAGNER (2010): "Higher productivity in importing German manufacturing firms: self- selection, learning from importing, or both?" *Review of World Economics*, 145, 641–665.
- WERNERFELT, B. (1984): "A resource-based view of the firm," *Strategic Management Journal*, 5, 171–180.

Notes

¹ Popular size-dependent policies across the world include but not limited to product market regulations in Japanese retail industry (Lewis, 2005), labour regulations applicable for large enterprises in France (Garicano et al., 2016), financial subsidies and incentives given for Small and Medium Scale Enterprises in Korea and India (Rotemberg, 2019), the small business financing program in Canada (Chandler, 2012), The United States Small Business Job Act(2010) that provide a range of credit opportunities and tax incentives for small enterprises, The Small business Act for Europe 2008, seeking to reduce the regulatory burden of small enterprises and SME Promotion Law in China (2002) allocating a portion of the central budget for the promotion of SMEs across a variety of purposes including credit assistance, technological up-gradation, exports, labour training, environmental protection etc. and to name a lot.

² <https://samadhaan.msme.gov.in/WriteReadData/DocumentFile/MSMED2006act.pdf>

³ Only 13 percent of units in our sample employ less than 10 employees in our sample

⁴ In one among the series of papers by GKPT that cover the time period from 1989 to 2003, Goldberg et al. (2010b) mention the main rationale to use CMIE Prowess is that though ASI gives product level information of manufacturing plants, the datasets are not available in panel format. However, we were fortunate to get access to the panel dataset with unique factory identifiers covering from 1998-99 to 2015-16, thanks to Ministry of Statistics and Programme Implementation, Government of India.

⁵ National Product Classification for Manufacturing Sector (NPCMS) is a classification system used in India to categorize manufacturing products based on their characteristics and uses. The classification system includes a hierarchical structure that groups products into broader categories and subcategories. The NPCMS is used to collect and analyze data on manufacturing products in India, particularly by the Central Statistical Office (CSO). The classification is periodically revised to keep pace with changes in the manufacturing sector

⁶ The concordance table provided by the Central Statistical Office (CSO) of India from ASICC 2009 to NPC-MS 2011 can be accessed from

<http://www.csoisw.gov.in/cms/cms/Files/181.pdf>

⁷ SSI products list and year-wise de-reservation list can be accessed from

<https://www.dcmsme.gov.in/publications/reserveditems/resvex.htm>

⁸ Industry-wise Wholesale Price Index data could be accessed from Office of the economic advisor, Government of India at <https://eaindustry.nic.in/>

⁹ Plant age and size is proxied with the logarithmic value of age and number of employees. Other variables - sales, working capital, cash holdings and staff welfare expenses are in million INR, but deflated with industry-wise Wholesale Price Index.

¹⁰ In our sample, we see that 71 percent of new entrant units were incorporated before 2001.

Rule of Extractive Informal Institutions in Democracy: Implications for Regional Disparity in Odisha

Laxmikanta Gual

national institute of science education and research (NISER), India

Abstract

In this paper we seek answers for the prevalence of wide regional disparities within democratic nations. We have examined the historical roots and prevalent characteristics of the formal and informal institutions in democratic state. We argue that the interaction between formal and informal institutions is a key determinant of regional development outcomes. The best development payoffs are enjoyed when both formal and informal institutions are inclusive. The worst comes when both the formal and informal institutions are extractive. We observe that at the initial stages of democracy, extractive informal institutions rule over formal democratic institutions. As a result, democratic institutions fail to bring drastic changes in the institutional order. We argue that political democracy per se cannot provide equal opportunities for all individuals and all regions of a state in the absence of social democracy. Although democracy ensures all citizens equal opportunity to contest elections, power remains concentrated with the historically dominant caste and class.

To make our case, we have taken the case of Odisha, a low-income state within the largest democracy of the world, India. The prevalence of wide development disparity amidst democratic institutions and political stability makes it a special case for inquiry.

Key Words: Regional Disparity, Extractive Institutions, Informal Institutions, Economic History, Democracy

JEL Codes: R11, R12, O18, B52, N90, K00

1. Introduction

The institutional economics literature usually acknowledges the quality of formal institutions for explaining the development disparity among different nations. A country's formal institutions, such as constitutional laws, are usually the same for all regions. Then how do we explain the prevalence of wide regional disparities within democratic nations? We argue that the development outcomes of different regions depend on the interaction between formal and informal institutions. The best development payoffs are enjoyed when both formal and informal institutions are inclusive. The worst comes when both the formal and informal institutions are extractive. Extractive informal institutions dominate over inclusive formal institutions when social norms govern most people in a society. At the initial stages of democracy, extractive informal institutions rule over formal democratic institutions.

1.1 Five Hypotheses to Understand Development Disparities

Apart from the conventional factors of economic growth, such as human capital, physical capital, technology and infrastructure five major strands can be adopted to explain the development disparities across nations or states: (i) geography hypothesis, (ii) culture hypothesis, (iii) ignorance or leadership hypothesis, (iv) trade or integration hypothesis, and (v) institution hypothesis. Economists like Montesquieu (1989), Diamond (1998), Gallup et al. (Gallup et al., 1999), and Easterly and Levine (2003) advocate that geographical factors like climate, natural resources endowment, disease burden, and transport costs can cause differences in development. For example, the tropic regions are poorer than the temperate regions due to the difference in climate that determines the productivity of land and labourer. Similarly, the culture hypothesis of Max Weber propagates that the Protestant religion and ethics are conducive to economic development and play an essential role in the establishment of modern industrial society in Western Europe. Over time, the culture hypothesis goes beyond religion and extends to other beliefs, values, and ethics. Economists like Lerner (1972) and Williamson (1990) postulate that some nations are poor because their rulers do not know how to make their countries rich. Another group of economists (Frankel & Romer, 2017; Sachs et al., 1995) emphasize the role of international trade or integration in reducing the gap between rich and poor regions. The moderate version of integration hypothesis claims that international trade or integration is an underlying source of growth, while the maximal version hypothesizes that integration is the key to the determinant of growth. Finally, the institutional hypothesis claims that the difference in institutional type is the fundamental determinant of differences in economic development (Acemoglu et al., 2001, 2004; Acemoglu & Robinson,

2012; Hall & Jones, 1999; Knack & Keefer, 1995; Mankiw et al., 1992; North, 1990; North & Thomas, 1973).

Institutions have a significant and quantitatively large effect on the economic prosperity of the modern world (Acemoglu & Robinson, 2012; Lloyd & Lee, 2018; Rodrik et al., 2004) than other fundamental factors.

2. Institution Hypothesis

Douglass C. North in his seminal paper (1991) defined institutions as "the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction." The informal institutions comprise of the costumes, traditions, and unwritten codes of conduct, while the formal institutions include written and constitutional rules, regulations, and laws. North opines that "institutions provide the incentive structure of an economy; as that structure evolves, it shapes the direction of economic change towards growth, stagnation, or decline" (North, 1991). Which institutions matter and how much it matters are still debatable and evolving. The recent institutional economics literature widely discusses how tax laws, legal regulations, political freedoms, democracy, property rights, religion, and infrastructure shape the development outcomes (Casson et al., 2010). The two most influential and largely cited institutions are the rule of law and property rights (Lee, 2016).

La Porta, et al., (2008) found that legal traditions such as common law have more impact on freedom to contract and exchange than civil law. Works of Torsten Persson and Guido Tabellini, and Besley and Persson (2009) show that different electoral rules and legislative regimes have different effects on economic development and public policy, such as government spending. Tabellini (2010), Gorodmichenko and Roland (2011) have assessed the impact of cultural institutions on economic development and prosperity. Tabellini argues that cultures and trust are important determinants of regional development. A growing body of literature led by Acemoglu and Robinson claims the impact of historically developed institutions, especially during the colonial period, on modern world prosperity.

Acemoglu and Robinson have shown that countries prosper only when they have inclusive political and economic institutions and fail with extractive political and economic institutions. Inclusive or good institutions are those institutions that include a wider section of society in the development process and ensure equity among social groups, classes, and individual actors in relation to the judicial system, public service provision, and private property rights. On the contrary, extractive or bad institutions are the institutions that exclude the majority from the development process to benefit a few elites associated with the rulers. They tend to develop and perpetuate inequality and hierarchy in the society through unequal distribution of wealth and power. The presence of extractive institutions discourages and oppose private property

rights, technology and innovation. Why bad institutions persist over time? And why institutions do not evolve in some societies.

2.1. Historical Roots of the Institution

The answer can be given in terms of historical process (Acemoglu & Robinson, 2012) and the degree of formality of institutions (Williamson, 2000). The political process in the past decides what type of institutions a society develops and how these institutions evolve over time. Acemoglu and Robinson claim that colonial history is responsible for the present-day differences in the prosperity of nations. Similarly, Williamson claims that societies dominated by informal institutions such as social norms and customs will take longer time horizon for potential change or shift in institutional order. Researchers use historical narratives and natural experiments to demonstrate the impact of institutions on development (Moriss, 2010; Noriss, 2012; Hannan, 2013; Acemoglu & Robinson, 2012). We adopt the historical narrative method to understand the uneven economic development in Odisha. We argue that Odisha's colonial history has an enduring impact on the regional disparity.

The rest of the paper is organised as follows. Section 3 discusses the historical roots of under- development and regional disparity in Odisha. Section 4 provides the empirical evidences on the extent and trend of regional disparity in the state. In section 5 we have theorized why and how regional disparity persists in democratic nations. Finally, we conclude with some policy suggestions in section 6.

3. Historical Roots of Under-development of Odisha

Several studies have pointed out that colonial institutions have a substantial effect on post- colonial development paths (Acemoglu et al., 2001; Acemoglu & Robinson, 2012; Anderson et al., 2015; Banerjee & Iyer, 2005; ENGERMAN & SOKOLOFF, 2005; Engerman & Sokoloff, 2002; Fredriksson & Gupta, 2022; Porta et al., 1999).

3.1. Rule of Mughal, Maratha and British

The Mughal rule (1578-1751) splits Odisha into a fertile coastal plain (moghulbandi area) that comes under the direct rule of the Mughals and the hilly, forested hinterlands (garhjat states), based on geography, ecology, economy. In 1751, the Marathas took over Odisha, and then the British occupied the coastal belt of Odisha and incorporated it into the Bengal Presidency in 1803- 04. The British rule divided Odisha into British India, incorporating the directly controlled coastal districts of Puri, Cuttack, and Balasore, and the princely states (also known as "tributary states" or "feudatory states), consisting of the districts in western Odisha. On April 1, 1936, Odisha became a separate province comprising seven districts and 26 princely states. Odisha lost two princely states (Saraikela and Kharswan) in 1948 and merged the remaining 25

princely states and seven districts to create 13 districts. In 1992, Odisha reconstituted these 13 districts into 30 districts having 314 blocks. Out of 30 districts, six districts, namely Mayurbhanj, Sudnargarh, Koraput, Nabarangpur, Rayagada, and Malkangiri (8 districts as per the 2011 census, including Gajapati and Kandhamal) are scheduled areas with more than 50% of the tribal population. Apart from these eight districts, five others include some scheduled areas with predominantly tribal populations. These are Balasore (Nilgiri Block), Kendujhar (Kendujhar and Champua Blocks), Sambalpur (Kuchinda Block), Ganjam (Soroda Block), Kalahandi (Thuamul Rampur and Lanjigarh Blocks) districts.

3.2. Infrastructure and Property Rights

Most of the coastal districts (like Puri, Cuttack, Balasore, and Ganjam) are developed mainly because the headquarters of the Odisha division was Cuttack, and the railway lines passed through these districts from Kolkata (headquarters of Bengal Presidency) to Madras (headquarters of Madras Presidency). The inherent bias of the British in favour of urban areas led to the concentration of modernized transport systems, including railways and education systems with schools and colleges, and health systems, including hospitals and medical colleges in the coastal belt. Most of the princely states were rich in natural resources, which served the British interest in raw materials. Thus only some areas in the princely states are developed, and the peripheries remain backward. The areas not serving any interests of the British Government, particularly the Hilly areas, remained at the lowest levels of development.

3.2.1. Forest and Common Property Resources

This colonial legacy of controlling forests and excluding the local people continues even after independence. The forest department still controls storage, transit, processing, and harassing traders. Exploitative trade practices such as forward trading, distress selling, and unfair weighing are prevalent in the NTFP market. The influence of village chiefs and the local-level multiple-buyer system in the market has been undermined drastically (Anderson et al., 2015; Pati, 2018). The recently enacted Forest Rights Act aims to provide forest dwellers with individual and community land rights. Government policies and institutions in Odisha have done little to improve the forest dwellers' livelihoods, mainly depending on collecting NTFPs. In order to protect the rights of mining companies, forest department officials show reluctance to issue community rights on forest lands. Although the new NTFP policy has vested powers in the hands of Panchayats, the situation in the market has remained the same. The local traders control half of the NTFP trade by controlling the local credit and product markets. Many forest villages need roads, mobile networks, electricity, and drinking water facilities. Taking the plea of difficulties in forest

clearance, line department officials do not take up any projects for the tribal villages to provide them with essential public goods.

3.2.2. Land Rights

Different land revenue laws shaped land systems differently in different parts of Odisha during the colonial period. Pati (2018, pp. 3-4) writes, "Whereas land settlement with the princely states and Zamindars (landlords) were made on a long-term, permanent basis, parts of the coastal tracts which were directly under the British only experienced temporary settlements." Thus land revenue institutions in the princely states were more extractive compared to coastal tracts. While social stratification has pre-colonial origins in Odisha, the additional tax burden on people living under permanent settlements further reinforced the social divisions. In order to bring equity in land holdings, the Government introduced land reforms without much effect. The current land administrative system is almost a legacy of the colonial period (Acemoglu et al., 2001; Banerjee and Iyer, 2005; Fredriksson and Gupta, 2022). Bans on the tenancy system and on selling tribal land to non-tribals have done little in Odisha to protect the land rights of the rural poor and tribals.

3.2.3. Development Projects Induced Displacement

The implementation of development projects has caused the large-scale displacement of Dalits, tribals, and poor peasants in Odisha (Padhi & Sadangi, 2020; Pati, 2018; Strümpell, 2014). Saxena (2003) estimates that almost three to five million people have been displaced in Odisha due to various development projects since independence, out of which more than 50 percent of people are Adivasis. Padhi and Sadangi have portrayed the post-colonial history of Odisha as a history of forced dispossession, state repression, and the resistance by Tribals and Dalits against it. While the forest communities sacrifice their land, lives, and livelihoods for development projects- for the considerable national interest, the nation hardly pays attention to their development needs.. There are instances of the same communities being displaced multiple times.

Padhi and Sadangi (2020) opine that the state join hands with multinational companies to evacuate the native people without adequate compensation. The extractive practice of exploiting mineral resources, and forceful displacement of tribals and Dalits continues from the colonial era. A very high proportion of the population in mineral-rich districts like Jharsuguda, Koraput, and Kendujhar live below the poverty line. This reflects how institutions regulating natural resources benefit only a few pockets, especially capitalists and elites, leaving the majority in poverty. Thus the signs of the resource curse in Odisha point toward the presence of extractive institutions.

4. Manifestation of Regional Disparity in Odisha

In 2020-21 Odisha had a per capita income of INR 1, 01, 501 (USD 1230) against the national average of INR 1,26,855 (USD 1537). While Odisha is one of India's fastest-growing state economies, it is also one of the most unequal states (de Haan, 2008; Haan, 2005; NITI Aayog, 2021; Sahoo & Senapati, 2022). The incidence of poverty in half of Odisha's districts is alarming. One in every two persons in these districts is multidimensionally poor (NITI Aayog, 2021). The undivided southern districts of Koraput, Bolangir, and Kalahandi (KBK) have the highest concentration of poverty. Historically, the coastal regions of Odisha enjoy a higher income, better infrastructure, and better human development indicators compared to the non-coastal regions with higher poverty and illiteracy incidence. The headcount poverty among the tribal population is more than double that of the non-tribal population in Odisha (NITI Aayog, 2021).

4.1. Regional Disparity in 1994

The Report of the Committee on the Constitutions of Separate Development Board in Odisha (RCCSDBO), 1994 categorized all 314 blocks of Odisha into the following four categories: 82 blocks as very backward, 87 as backward, 70 as developing, and 75 as developed blocks (RCCSDBO, 1994). The Committee categorised 54 percent of blocks in the state as backward or very backward. 80 per cent of backward and very backward blocks belong to tribal concentrated districts such as Koraput, Malkangir, Balangir, Kandhamal, Mayurbhanj, Rayagada, and Gajapati, situated in the southern pocket of Odisha.

4.2. Regional Disparity in 2008

The "Regional Imbalance Enquiry Commission (RIEC)", 2008 used 26 district-level Indicators and 14 block-level indicators and based on the composite index, classified regions under different development categories, respectively. The RIEC categorised 50 percent of districts and 53 percent of blocks in the state as either backward or very backward (RIEC, 2008). The backward and very backward blocks are mostly tribal-dominated areas in Odisha's South and West parts. The very backward districts were Malkangiri, Kandhamal, Nabarangpur, Deogarh, Nuapada, Mayurbhanj, Kalahandi, and Gajapati.

4.3. Regional Disparity in 2021

The Multi-dimensional Poverty Index published by the NITI Aayog (2021) used 12 broad indicators such as health and nutrition, education and standard of living from the National Family Health Survey (NFHS) 2015-16 data set. According to this report, nearly 30 percent of households in Odisha are poor. Almost in half of the districts of Odisha, one in every two persons is multidimensionally poor. Southern Districts like Nabarangpur, Malkangiri, Koraput, Rayagada, and Kalahandi have the highest concentration of poverty.

Most of the southern and other selected northern districts with a high Adivasi population have a higher incidence of poverty.

4.4. Development Gaps: Coastal Vs Non-Coastal; Tribal Vs Non-tribal regions of Odisha

To understand Odisha's regional disparities, we have compared the socioeconomic indicators across three National Sample Survey regions (South, North, and Coastal) and tribal versus non-tribal districts. Table 1 compares the selected socioeconomic indicators across three NSS regions vis-a-vis the state average and compares the same indicators among tribal and non-tribal districts of Odisha.

Table 1: Poverty, Human Development, and Infrastructure Disparities across South, North, and Coastal Odisha, Tribal and Non-tribal regions

Indicators	South	North	Coastal	Odisha	Tribal Regions	Non-tribal Regions
Population						
a. Total Population (in number)	1,16,50,067	1,20,35,361	1,82,88,790	4,19,74,218	10105798	31868420
b. Share of SC population (%)	16.9	16.4	17.8	17.1	11.7	18.8
c. Share of ST population (%)	32.7	29.5	12.2	22.8	54.7	12.8
Economic Status						
a) Poverty headcount (%)	44.1	28.2	21.5	29.5	46	24
Human Development:						
a. literacy (Education)	59.8	76	74.9	72.9	56	76
b. % Children Underweight (Health)	41	39.25	26.2	30.2	39	27
Infrastructure:						
a. Number of Junior college	371	477	758	1606	328	1278
b. Number of Degree College	173	252	416	841	158	683
c. Number of Hospitals & Medical Colleges	535	498	721	1754	506	1248
d. Banking: Branch Network (in number)	1208	1565	2677	5450	1083	4367
Infrastructure per one lakh population						
a. Number of Junior college	3	4	4	4	3	4
b. Number of Degree College	1	2	2	2	2	2
c. Number of Hospitals & Medical Colleges	5	4	4	4	5	4
d. Banking: Branch Network (in number)	10	13	15	13	11	14
Infrastructure per one thousand Square KMs						
a. Number of Junior college	5.9	8.6	19.9	10.3	5.5	13.3
b. Number of Degree College	2.8	4.6	10.9	5.4	2.7	7.1
c. Number of Hospitals & Medical Colleges	8.6	9.0	18.9	11.3	8.5	13.0
d. Banking: Branch Network (in number)	19.4	28.3	70.3	35.0	18.2	45.4

Source: Population and literacy data from the census (2011), poverty data from the NITI Aayog Report (2021), Underweight data from NFHS-5 (2021), & Infrastructure data from the Handbook of Statistics (2020)

Southern districts have a higher concentration of tribal population (32%), followed by Northern (29%) and Coastal regions (12%). Similarly, the Poverty headcount ratio in southern Odisha (44.10%) is more than double of coastal Odisha (21.46%) and almost one and half times that of North Odisha (28.19%). The literacy rate is lower in the Southern region (60%) compared to the North (76%) and South (75%) regions of Odisha. The percentage of underweight children is very high in both Southern (41%) and Northern Odisha (39%) compared to Coastal Odisha (26%). There is also a considerable gap between Southern-Northern regions and Coastal regions in the availability of basic

infrastructure. The number of colleges, hospitals, and banks is drastically lower in south and north Odisha compared to the Coastal region. Tribal districts are sparsely populated. Therefore, we have compared the availability of basic infrastructure per one thousand square KMs. The southern region is the most backward in all indicators, followed by the northern districts.

We have compared the poverty, human development, and infrastructure disparities across tribal and non-tribal regions. We have grouped districts under tribal and non-tribal regions based on the scheduled tribe population. Districts, where the ST population is more than 50 percent of the total population are categorized as tribal regions. These districts are Koraput (50.6 %), Sundargarh (50.7%), Kandhamal (53.6%), Gajapati (54.3%), Nabarangpur (55.8%), Rayagada (56%), Malkangiri (57.8%), and Mayurbhanj (58.7%). The reason for choosing 50 percent and above is that the districts with more than 50 percent ST population are categorized as Scheduled areas. The remaining districts of Odisha, where the ST population is less than 50 percent, are categorized as non-tribal districts. The average ST population in the Tribal regions is 54 percent, compared to only 12 percent in the non-tribal region. The incidence of poverty in the tribal region (46 per cent) is almost double that of the non-tribal regions (24 per cent).

The tribal region lags in other human development indicators and economic infrastructure compared to the non-tribal regions. In the education and health infrastructure availability per one lakh population, we do not find a significant difference between tribal and non-tribal regions. However, when we standardize the same indicators per thousand square KMs, we find significant differences. The tribal population is sparsely located in the tribal region. Culturally tribal people reside in small hamlets inside the forest or in the vicinity of forests. Due to the presence of educational institutions in far-off places and the absence of good roads and transportation facilities, only a few children go to the secondary and tertiary levels of education. Distance to educational institutions such as schools and colleges can be a significant barrier to achieving educational output (Das & Das, 2023). The number of junior colleges, degree colleges, hospitals, and medical colleges per one thousand square KM in the tribal region is almost half of the non-tribal regions. The number of bank branches for one thousand square KM in tribal areas is less than half of the non-tribal areas.

Thus there is a clear divide between the coastal and non-coastal districts and tribal and non-tribal regions over the last three decades. We seek answers to these issues in the following section.

5. Theorizing Regional Disparity of Odisha

The seeds of uneven economic development of Odisha was shown during the colonial regime. Be it land tenure system, or forest rights, development of railway and road infrastructure, or extraction of minerals, forced displacement

or establishment of educational and health institutions, the roots of disparities can be traced back to the colonial rule. With and without the support of the Union government, the state government has undertaken several policy measures to address the issues of regional disparity. But such policies have mixed results. The failure of welfare policies, in a democratic structure, points figure towards to institutional architecture. A number of researchers point out that democracy creates an environment that leads to an automatic correction of inequality (Meltzer & Richard, 1981), reduction of poverty (Sen, 1982), and inclusive economic development (Acemoglu & Robinson, 2012). This is due to the inherent tendency of democracy towards pro-poor policies and the fundamental principles of equality. But why this has not happened in Odisha?

Political democracy per se cannot provide equal opportunities for all individuals and all regions of a state in the absence of social democracy. By social democracy we refer to the equal opportunities enjoyed by each individual irrespective of caste, class, and gender. In a multiparty democratic nation like India, although all citizens have equal opportunity to contest elections, power remains concentrated with the historically dominant caste and class. The payoff is negative when extractive social institutions dominate constitutional rights or supposedly inclusive formal institutions. In an ideal context, constitutional rights should dominate social institutions and lead to an inclusive society. Unless a critical number of individuals move out of the clutches of the extractive social institutions, the payoffs will be negative.

Table 2 presents four alternative scenarios of the interaction between inclusive or extractive formal institutions and inclusive or extractive informal institutions. The best social and economic payoffs are enjoyed when both formal and informal institutions are inclusive. The worst will come if formal and informal institutions are extractive. If formal institutions are extractive but informal institutions are inclusive, we may expect gradual strengthening of the formal institution. Social pressure from an inclusive society will pressure formal institutions to bring amendments and correct discriminatory legislation. However, if informal institutions are extractive and formal institutions are inclusive, we may face two scenarios. Extractive informal institutions dominate over inclusive formal institutions when social norms govern most people. However, with individual economic development, there will be a tendency among the people to take advantage of inclusive formal institutions and get rid of the extractive practices of extractive informal institutions. Once the number reaches a necessary minimum, there will be a big push toward adopting inclusive formal institutions and corrections in the social norms. In some societies, this may take quite a long time. Societies can move from extractive informal and formal institutions to inclusive formal and informal institutions in both ways (inclusive informal and extractive formal or inclusive formal and extractive informal).

Table 2: Interaction between formal and informal institutions and the payoffs

	Inclusive Formal	Extractive Formal
Inclusive Informal	Inclusive development	Gradual strengthening of the formal institutions
Extractive informal	Improvement informal institutions may or may nothappen	The worst form of disparities

Bridges (2018) opines that power relations within institutions are crucial in shaping social and economic progress. In democratic states also, all individuals are equally not capable. Inclusive institutions should create enabling fields for different sections of society. Nevertheless, it is observed that even within democratic states, all people and regions do not have equal access to government institutions. The powerful social and economic groups and specific regions, especially those living closer to the center, enjoy more benefits from the government institutions.

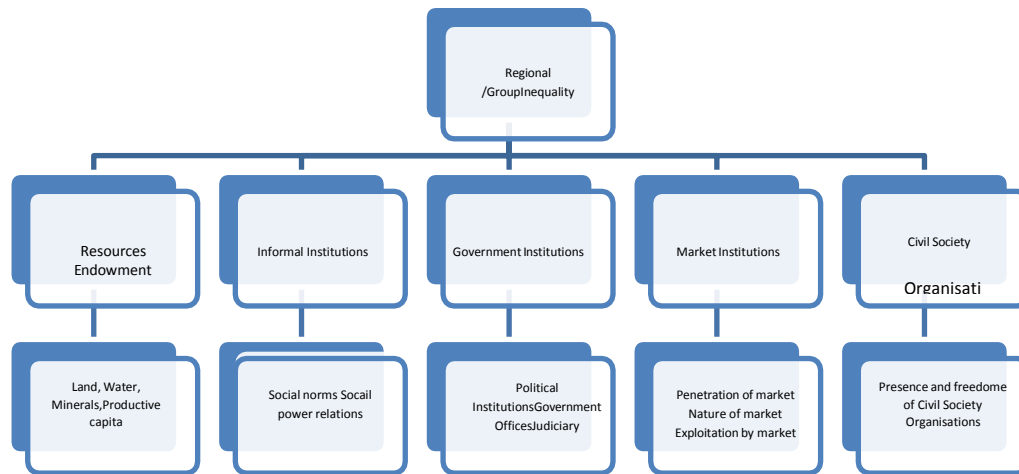
5.1. Rule of Informal Institutions in Democracy

Democracy in India is only 75 years old. The informal institutions are much older than the democratic institution. In an ideal condition, formal democratic institutions should prevail over the informal institutions in case of any divergence. However, in many cases, extractive informal institutions rule over the democratic institutions. For example, democracy provides equal opportunity for every citizen to contest elections. Nevertheless, in reality, politics in India is captured by the elites. Former landlords, political and business leaders enter into politics. The majority of the elected representatives inherit the power from their family. Interestingly, people have been accepting these undemocratic practices in the democracy. Similarly, the role of caste identity in the electoral politics are some of the indicators of the rule of informal institutions over the democratic institutions. These practices are commonplace in the backward regions. Unlike autocratic system, democracy does not allow the lawmakers and executive wings to enforce the rules strictly. In fear of public dissent and losing power, the political leadership is always afraid of imposing the inclusive rules that may go against the extractive informal institutions. Increase in the educational achievements can empower the people to fight against the extractive informal institutions and demand for the implementation of the rule of law. However, this process will take long time than expected.

In the following sections, we elaborate on the extractive nature of different institutions that operate within a democratic state.

Regional or group inequality can be shaped by a plethora of factors like resource endowments, informal institutions, government/formal institutions, market institutions and civil society organizations.

Figure 1: Conceptual Framework for understanding the Regional Disparity



5.1.1. Resource Endowment

Inclusive institutions should create equal opportunities for all sections of society to realize one's potential and create an adequate level of income/wealth for maintaining a decent quality of life. For individuals, a resource could refer to the levels of education of the family members, land holding, social network, and other forms of wealth. For a region of a state or nation, resources would refer to the endowment of natural resources such as minerals, water, forest, fertile soil, availability of social (schools, colleges, hospitals, etc.) and economic (roads, irrigation facilities, banks, industries, etc.) infrastructure. Institutions play the most crucial role in transforming resource endowments into income or wealth. Good informal institutions (such as good social norms), formal institutions (such as well-functioning government offices), market development, and civil society organization would facilitate the transformation of the initial resource endowments to higher income and wealth levels. On the other hand, poor/extractive institutions would be detrimental to the positive transformation of the initial endowments and instead work in a regressive manner. In the absence of equal initial resource endowments and good informal institutions and markets, States should create formal institutions to provide equal opportunities for all sections of society to realize their potential.

5.1.2. Informal Institutions

Informal institutions include social norms, rules, regulations, beliefs, caste and religious institutions, customs, and traditions. Some informal institutions are very helpful for social and economic progress. However, some other informal institutions create impediments to the progress.

Discrimination based on caste, religion, and sex can perpetuate inequalities. With economic advancement, some social norms change and accept good

practices. However, in some regions, informal institutions remain extractive. The caste system determines the power relations in rural areas and prohibits the lower social groups from accessing many spaces that would have provided them economic mobility. People with good resource endowments, such as wealth, social networks, and education, can overcome the constraints imposed by informal institutions and achieve economic and social mobility. At the same time, households with low resource endowments cannot do so but instead get entrapped within the regressive social constraints. Due to inadequate deployment of human resources within the law enforcement departments and judiciary, lack of strong political willpower, and dominance of the upper class within formal institutions, enforcement of laws against the regressive informal institutions remains weak.

The backward regions of Odisha are historically characterized by a heterogeneous population (Pati, 2018). The diversity among the population and different regional groups did not allow them to mobilize and stand uniformly to fight for their democratic rights since the colonial period. Formal institutions also contribute to the improvement of informal institutions. The interdependencies and interactions between them determine the regional economic development outcomes. In Odisha, the quality of formal institutions is a major constraint in this regard. Community or local institutions are also weak and passive, resulting in the perpetual backwardness of certain regions despite numerous government schemes.

5.1.3. Government Institutions

The primary goals of government institutions are to create equal opportunities for all sections of society and regions. Government institutions should correct the imperfections in the market, and informal institutions to create enabling fields for all. Equal access to government institutions is the key to creating an egalitarian society. However, there are many instances of unequal access to government institutions by different sections of society. A slew of factors could be responsible for this. Ignorance of people, ambiguity in the rules and regulations, the approach of government officials, and corruption in government offices remain barriers to accessing government offices. In democratic states, different political, social, and economic statuses determine the access to government offices and availing the services.

India's number of government officials for one lakh population is much lower than that of the developed countries. Many vacancies in the sanctioned positions and the absence of government officials in offices during duty hours are quite commonplace in remote locations. Such officials use their political and social networks to get rid of the rules and regulations. Thus, the delivery of public services by government officials depends upon the geographical location, awareness of the citizens, and socioeconomic status of the individuals.

The corrupt officials do not face protest either because the local elites do not use the public service or because their needs are fulfilled incredibly.

The distribution of resources in democratic states also differs across regions. Within democratic states, the elites and powerful, influential groups also enjoy the benefits of public resources than others due to personal networking and corrupt practices. Government institutions are also dominated by the extractive informal institutions. Historically privileged groups have more access to the government institutions than others. Use of social network, instead of merit, has undermined the efficiency of government institutions and rule based public service delivery. Similarly, underrepresentation of people from different social groups and regions in government offices also undermines the public service delivery.

5.1.4. Market Institutions

Adam Smith noted that freedom of exchange and transaction is part and parcel of the fundamental liberties people have reason to value. According to Sen (2000), the freedom to enter markets can itself be a significant contribution to development, keeping aside the fact that the market mechanism may or may not do to promote economic growth or industrialization. Markets do not function competitively in all regions. Although conceptually, the market does not refer to any physical space, geographical locations have implications for market functioning. Due to the rise in online transactions, the general notion would be that people can have equal access to the market irrespective of their geographical locations. However, people living in remote locations face difficulties participating in the market exchange as buyers and sellers. Due to limited internet access and ignorance, many people cannot participate in online market exchange. The online market has increased the vulnerability of not-so-educated people by increasing their exposure to online fraud. Due to limited demand market does not grow in remote locations. Similarly, producers of remote areas cannot sell their products at a competitive price because of the monopsony or oligopsony nature of the market. Thus, be it the labor market, product, or input, the market conditions faced by people in remote locations are imperfect.

5.1.6. Civil Society Organisations

The role of Civil Society organizations has been growing in democratic nations. CSOs have the freedom to operate in the domains as much as the terms and conditions set by the funding agencies. Therefore, the CSOs will not be able to protest against the extractive institutions. In India, corporate funding for CSOs is limited. A large number of NGOs are engaged in the implementation of government projects at grassroots levels. In such a situation, CSOs have minimal scope to function independently. International and national private funding comes with several strings attached. Therefore, CSOs cannot point out

the limitations of government institutions and corporate entities. Moreover, to execute their routine work with the communities, they must keep harmony with the local communities and elites. Going against the vested interests of the local elites may ruffle. In Odisha, the contribution of civil society is insignificant and passive.

6. Conclusion

In this paper, we have tried to understand why some regions remain perpetually backward even within democratic nations. We took the case of Odisha to answer this question. From a systematic review of the literature, we found alternative hypotheses such as geography, culture, Ignorance/Leadership quality, global integration, and quality of the institution, in explaining the uneven development process. We used historical narrative method and relied on the institutional hypothesis to explain the regional Disparity in Odisha. While the institutionalists claim that inclusive or good institutions like democracy provide equal opportunities for all individuals and all regions to prosper, social democracy is important in ensuring balanced regional development.

We observed that the seeds of uneven economic development in Odisha are rooted in colonial history. The interaction of formal and informal institutions determines the level of development of a region. The best social and economic payoffs are enjoyed when both formal and informal institutions are inclusive. The worst will come if formal and informal institutions are extractive. Extractive informal institutions dominate over inclusive formal institutions when social norms govern most people in society. In fear of losing power the democratically elected governments do not strictly implement the rule of law and wait for the social acceptance of the formal rules.

The backward regions witness stronger prevalence of the rule of informal institutions over the inclusive formal institutions. Increase in the educational achievements can empower the people to fight against the extractive informal institutions and demand for the implementation of the rule of law. However, this process will take long time than expected. We find the prevalence of strong extractive informal institutions and weak inclusive formal institutions in the backward regions of Odisha. The rule of the extractive informal institutions over the supposedly inclusive formal institutions perpetuates the vicious circle of backwardness in the state.

References

- Acemoglu, D., Johnson, S., & Robinson, J. (2004). Institutions As the Fundamental Cause of Long- Run Growth. *Handbook of Economic Growth*, 1, 1-3.
- Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The Colonial Origins of Comparative Development: An Empirical Investigation. *American Economic Review*, 91(5), 1369-1401. <https://doi.org/10.1257/aer.91.5.1369>
- Acemoglu, D., & Robinson, J. A. (2012). *Why Nations Fail: The Origins of Power, Prosperity and Poverty* (1st ed., Vol. 529). Crown.
- Anderson, S., Francois, P., & Kotwal, A. (2015). Clientelism in Indian Villages. *American Economic Review*, 105(6), 1780-1816. <https://doi.org/10.1257/aer.20130623>
- Banerjee, A., & Iyer, L. (2005). History, Institutions, and Economic Performance: The Legacy of Colonial Land Tenure Systems in India. *American Economic Review*, 95(4), 1190-1213. <https://doi.org/10.1257/0002828054825574>
- Besley, T., & Persson, T. (2009). The Origins of State Capacity: Property Rights, Taxation, and Politics. *American Economic Review*, 99(4), 1218-1244. <https://doi.org/10.1257/aer.99.4.1218>
- Bridges, M. M. (2018). *Extractive Practices in 'Inclusive' State: Power and Poverty in the USA*. London School of Economics.
- Casson, M. C., Giusta, M. Della, & Kambhampati, U. S. (2010). Formal and Informal Institutions and Development. *World Development*, 38(2), 137-141. <https://doi.org/10.1016/j.worlddev.2009.10.008>
- Charles de Montesquieu. (1989). *Montesquieu: The spirit of the laws* (A. M. Cohler, B. C. Miller, & H. S. Stone, Eds.). Cambridge University Press.
- Daimond, J. M. (1998). *Guns, germs and steel: a short history of everybody for the last 13,000 years*. Vintage.
- Daniel Hannan. (2013). *How we invented freedom & why it matters*. Bloomsbury Publishing.
- Das, B., & Das, A. (2023). Is Distance to Secondary School a Barrier to Secondary and Higher Education in India? *Millennial Asia*, 14(1), 102-126. <https://doi.org/10.1177/09763996211035073>
- de Haan, A. (2008). Inequalities within India's Poorest Regions: Why Do the Same Institutions Work Differently in Different Places? In A. J. Bebbington, A. A. Dani, A. de Haan, & M. Walton (Eds.), *PATHWAYS TO EQUITY* (pp. 103-136).
- Easterly, W., & Levine, R. (2003). Tropics, germs, and crops: how endowments influence economic development. *Journal of Monetary Economics*, 50(1), 3-39. [https://doi.org/10.1016/S0304-3932\(02\)00200-3](https://doi.org/10.1016/S0304-3932(02)00200-3)
- ENGERMAN, S. L., & SOKOLOFF, K. L. (2005). The Evolution of Suffrage Institutions in the New World. *The Journal of Economic History*, 65(04). <https://doi.org/10.1017/S0022050705000343>
- Engerman, S., & Sokoloff, K. (2002). Factor Endowments, Inequality, and Paths of Development Among New World Economics. <https://doi.org/10.3386/w9259>

- Frankel, J. A., & Romer, D. (2017). Does Trade Cause Growth? (pp. 255–276).
- Fredriksson, P. G., & Gupta, S. K. (2022). Land productivity and colonization. *Economic Modelling*, 113, 105890. <https://doi.org/10.1016/j.econmod.2022.105890>
- Gallup, J. L., Sachs, J. D., & Mellinger, A. D. (1999). Geography and Economic Development. *International Regional Science Review*, 22(2), 179–232. <https://doi.org/10.1177/016001799761012334>
- Gorodnichenko, Y., & Roland, G. (2011). Which Dimensions of Culture Matter for Long-Run Growth? *American Economic Review*, 101(3), 492–498. <https://doi.org/10.1257/aer.101.3.492>
- Haan, A. De. (2005). Poverty, disparities, or the development of underdevelopment in Orissa. *Economic and Political Weekly*, 40(22), 2321–2329. <http://www.jstor.org/stable/10.2307/4416712>
- Hall, R. E., & Jones, C. I. (1999). Why do Some Countries Produce So Much More Output Per Worker than Others? *The Quarterly Journal of Economics*, 114(1), 83–116. <https://doi.org/10.1162/003355399555954>
- Ian Morris. (2010). Why the west rules-for now: The patterns of history and what they reveal about the future. Profile books.
- Knack, S., & Keefer, P. (1995). INSTITUTIONS AND ECONOMIC PERFORMANCE: CROSS-COUNTRY TESTS USING ALTERNATIVE INSTITUTIONAL MEASURES. *Economics & Politics*, 7(3), 207–227. <https://doi.org/10.1111/j.1468-0343.1995.tb00111.x>
- Lloyd, P., & Lee, C. (2018). A REVIEW OF THE RECENT LITERATURE ON THE INSTITUTIONAL ECONOMICS ANALYSIS OF THE LONG-RUN PERFORMANCE OF NATIONS. *Journal of Economic Surveys*, 32(1), 1–22. <https://doi.org/10.1111/joes.12186>
- Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A Contribution to the Empirics of Economic Growth. *The Quarterly Journal of Economics*, 107(2), 407–437. <https://doi.org/10.2307/2118477>
- Meltzer, A. H., & Richard, S. F. (1981). A Rational Theory of the Size of Government. *Journal of Political Economy*, 89(5), 914–927. <https://doi.org/10.1086/261013>
- NITI Aayog. (2021). National Multidimensional Poverty Index. NITI Aayog.
- North, D. C. (1990). Institutions, Institutional Change and Economic Performance. Cambridge University Press. <https://doi.org/10.1017/CBO9780511808678>
- North, D. C., & Thomas, R. P. (1973). The rise of the western world: A new economic history. Cambridge University Press.
- Odisha (India). (1994). Report of the Committee on the Constitution of Separate Development Board in Odisha. Planning and Coordination Department, Government of Odisha.
- Odisha (India). (2008). Report of the Regional Imbalance Enquiry Commission Odisha. Padhi, R., & Sadangi, N. (2020). Resisting Dispossession. Springer Singapore. <https://doi.org/10.1007/978-981-15-0717-5>

- Pati, B. (2018). *Tribals and Dalits in Orissa: Towards a social history of exclusion, C. 1800–1950*. Oxford University Press.
- Pippa Norris. (2012). *Making democratic governance work: How regimes shape prosperity, welfare, and peace*. Cambridge University Press.
- Porta, R. La, Lopez-De-Silanes, F., & Shleifer, A. (1999). *Corporate Ownership Around the World*. The Journal of Finance, 54(2), 471–517. <https://doi.org/10.1111/0022-1082.00115>
- Porta, R. La, Lopez-de-Silanes, F., & Shleifer, A. (2008). The Economic Consequences of Legal Origins. *Journal of Economic Literature*, 46(2), 285–332. <https://doi.org/10.1257/jel.46.2.285>
- Rodrik, D., Subramanian, A., & Trebbi, F. (2004). Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development. *Journal of Economic Growth*, 9(2), 131–165. <https://doi.org/10.1023/B:JOEG.0000031425.72248.85>
- Sachs, J. D., Warner, A., Åslund, A., & Fischer, S. (1995). Economic Reform and the Process of Global Integration. In *Source: Brookings Papers on Economic Activity* (Vol. 1995, Issue 1, pp. 1–118). <https://about.jstor.org/terms>
- Sahoo, P., & Senapati, A. K. (2022). Growth and Regional Disparities in Odisha: An Analysis in the Post-reform Period. *Arthaniti: Journal of Economic Theory and Practice*, 21(2), 176–193. <https://doi.org/10.1177/0976747920961934>
- Sen, A. (1982). *Poverty and famines: an essay on entitlement and deprivation*. Oxford University Press.
- Sen, A. (2000). A Decade of Human Development. *Journal of Human Development*, 1(1), 17–23. <https://doi.org/10.1080/14649880050008746>
- Strümpell, C. (2014). The politics of dispossession in an Odishan steel town. *Contributions to Indian Sociology*, 48(1), 45–72. <https://doi.org/10.1177/0069966713502421>
- Tabellini, G. (2010). Culture and Institutions: Economic Development in the Regions of Europe. *Journal of the European Economic Association*, 8(4), 677–716. <https://doi.org/10.1111/j.1542-4774.2010.tb00537.x>
- Williamson, O. E. (2000). The New Institutional Economics: Taking Stock, Looking Ahead. *Journal of Economic Literature*, 38(3), 595–613. <https://doi.org/10.1257/jel.38.3.595>

Craft industry in Nova Scotia and Inclusive innovation

Fariba Seyedjafarrangraz, Claudia De Fuentes
Saint Mary's university, Canada

Abstract

Inclusive innovation is the process of developing new goods and services for the people that have been traditionally excluded. Despite its increasing interest, inclusive innovation has been under-researched in craft-based industries. This paper studies the inclusive innovation business in the craft industry in Nova Scotia. We focus on the craft wine industry and conceptualize it as an industry that, even though it relies on codified knowledge, has a high degree of tacit knowledge, and learning by doing and learning by interacting is quite important. We had access to five semi-structured interviews with winery owners and winemakers. Using a deductive- inductive process, we coded the data to identify the specificities of inclusive innovation in the industry. This study contributes to the discussion of the elements of the ladder of inclusive innovation as defined by (Heeks et al., 2013) regarding inclusion in terms of process, impact, and inclusive knowledge specific to the industry. Implications from this study to practitioners are the importance of introducing inclusive sources of business, which leads to scalable and effective inclusive innovation initiatives.

Key Words: Inclusive innovation, Nova Scotia, Craft industry

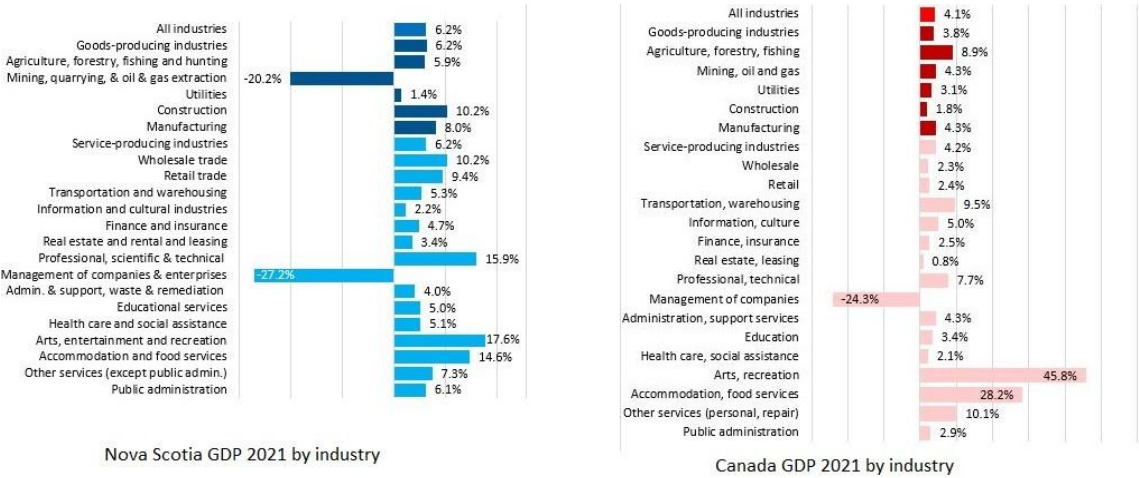
1. Introduction

While an increasing number of world economies are catching up and witnessing rapid technological development through the use of new innovative technologies such as machine learning and artificial intelligence, the craft industry in Nova Scotia has lagged far behind with regard to the accumulation of technological capabilities which is the ability of the company to execute any relevant technical function, including the ability to develop new products, processes, and technological knowledge in order to obtain higher levels of organizational efficiency (Tsai, 2004). For the craft industry, the technological capabilities are anchored in their nature and context. Nova Scotia has one of the highest shares of rural residents in Canada. In the Halifax Regional Municipality, an urban municipality along the Atlantic coast on mainland Nova Scotia, about one-third of the city's residents live. Rural areas and small population centers make up the rest of the province. It is estimated that 23% of Nova Scotians live in one of its 36 small population centers, while 43% live in rural areas outside of these centers (foundation, 2021). How these lagging economies in rural areas could upgrade is a matter of concern for academics and policymakers, including international organizations. In less developed regions, innovation is a crucial "ingredient" for development as it encompasses upgrading and capacity building (Lundvall, 2007). In developing regions, innovation systems differ significantly from those in developed ones (Arocena & Sutz, 2000). Typically less developed regions are characterized by deficient economic infrastructure, weaker institutional frameworks, and low levels of interaction between the actors in the innovation system.

Innovation systems describe how interactivity between system actors will orient innovation over time as relations and modes of learning change (Lundvall, 1992). Innovation is seen to merge through various categories of learning: learning by doing, as individuals build knowledge by engaging in production processes; learning by using, where learning relates to the adjustment that actors must make to ensure that new technologies fit particular tasks; and learning by interaction, where learning comes from working with other system actors (Foster & Heeks, 2013). Research in the innovation system tradition argues that innovation occurs through interaction between organizations located in specific national, regional, or sectoral institutional contexts (Balaguer, 2008). Knowledge is increasingly regarded as a critical resource for firms and economies. Much recent attention has focused on the importance of tacit knowledge (Winter, 1987), and we argue in this paper that the wine craft industry has a high component of tacit knowledge, where interactions amongst actors is crucial for the innovation process. Managing tacit knowledge is crucial for all organizations in today's global economy. To survive, succeed, and be innovative, organizations must deal with knowledge creation, transfer, and utilization (Al-Qdah & Salim, 2013).

Moving towards addressing innovation challenges in rural area requires understanding the whole innovation system. For doing so, we refer to inclusive innovation literature . According to Foster and Heeks, conventional views of innovation (often implicitly) equate development with economic growth. Inclusive innovation explicitly considers the inclusion of those excluded from mainstream development as an integral part of development. Since inclusive innovation differs in its foundational view of development, it refers to the inclusion of marginalized groups in some aspects of innovation (Heeks et al., 2013). In this study, we consider Nova scia rural context and tacit knowledge based craft industry to explore inclusive innovation.

Furthermore, in comparison to many other wine-growing regions around the world, Nova Scotia (NS) has a cooler climate and shorter growing seasons (NS, 2016). NS has flourished with French hybrids, and wine grape varieties bred to grow well in less than ideal conditions. As a result, unique wines have been produced in the region. Various grape varieties are in these categories, including Marechal Foch, Leon Millot, Baco noir, and Castel (Murray & Wright, 2004). Although Nova Scotia wine is unique, it is underperforming. As Figure 1, agriculture and food contribute to Province GDP by 5.9 %, this percentage in the whole of Canada is 8.9%.



Although there have been many valuable studies in the craft industry in recent years, a review of the literature shows that many of these studies focus more on the process and consumption, and regionality (B. Rinaldo et al., 2014; Barisan et al., 2015; McDermott, 2007). Less attention is paid to the inclusiveness of innovation, specifically in a rural region. Thus, this research seeks to understand better the inclusiveness of innovation of the craft industry in Nova Scotia. The main question that this study address is twofold. First, what initiatives of inclusive innovation are conducted in the craft wine industry in Nova Scotia? Second, do they align with the proposed ladded of inclusive innovation as elaborated by Foster (2013)? The research explores what factors

contribute to these inclusion gaps in the region. This research is significant because of the impact of the wine industry on Nova Scotia's economy, as it is shown in figure 2. Then, finding the state of inclusiveness is important for the scalability of this industry and getting advantages from its impact on the economy.



Using a qualitative research design, we interviewed five key informants that are either owners or master wine maker in this craft industry. We anchor the analysis using the inclusive innovation framework (Heeks et al., 2013). This study contributes to the discussion of the elements of the ladder of inclusive innovation as defined by (Heeks et al., 2013) regarding inclusion in terms of process, impact, and knowledge specific to the industry. Although (Heeks et al., 2013) focused on innovation for poor, low-income people, in this study, we find inclusive innovation in the craft wine industry which is based on tacit knowledge and is in the rural region.

The article is organized as follows. The next section reviews the main literature. Section three reports the methodology, research paradigm, and population of interest. In section four, we present the findings and the thematic analysis. In section five, we present our conclusions and limitations of the article.

Preview of Literature

Wine industry

According to (Rimerman & Eyler, 2013), Nova Scotia's wine industry is dominated by small producers who produce fewer than 10,000 cases per year. Despite this, the industry has had a positive impact on the province's economy and tourism. In 2011, the wine sector generated \$14.2 million in tourism and \$196.3 million in economic impact with 13 wineries. The wine industry in

Canada as a whole continues to grow, with wine sales increasing by 31.2% and valued at more than \$1 billion CAD from 2004-2012 (Wine & Association, 2016). As of 2012, there were 476 established wine producers in Canada, with 234 in Ontario and 171 in British Columbia, generating a revenue of \$1.1 billion (Wine & Association, 2016).

In Nova Scotia, the wine industry is also growing with over 20 wineries as of now, selling \$11.6 million of local wine in NS in 2015, up 12% from the previous year, with sales doubling in the last five years (Jantzi & McSweeney, 2019). In fact, the sales of Nova Scotia wine have exceeded those of French, Chilean, and Australian wines, making it a significant contributor to the economy (Jantzi & McSweeney, 2019).

Scholars are currently focusing on the overall impact of innovations on economic growth, though some studies concentrate on particular industries, such as the wine sector. The wine industry is a significant contributor to employment and revenue in various countries, and several researchers have examined how innovations have influenced its growth (Bigliardi & Galati, 2013). For example, one study highlighted that in a firm, innovation results from accumulating and integrating internal and external knowledge in various ways (Edquist, 2006). Several studies have shown that external knowledge sources are important for innovation (Chesborough, 2006; Lazzarotti & Manzini, 2009). There are also studies that emphasize the importance of internal capacities and resources to the ability of a firm to innovate (Becheikh et al., 2006; Freel, 2003). Finally, some studies suggest that internal and external knowledge acquisition can be complementary activities in a firm's innovation strategy (Doloreux et al., 2015; Vega - Jurado et al., 2009)

Innovation is a key factor in the wine industry's development. (Presenza et al., 2016) have emphasized that external knowledge sources are essential for the development of numerous innovations in the wine industry, given that innovation is a complex and uncertain process that often involves the collaboration of other companies in the value chain, including clients, suppliers, competitors, and knowledge-generating organizations such as universities. Furthermore, using new technologies and know-how, universities and scientists contribute to wine industry innovation (Giuliani et al., 2011). Bridging organizations, such as industry associations and public organizations, can also facilitate innovation (McDermott et al., 2009). Innovation can be facilitated by bridging organizations, such as industry associations and public organizations, according to (McDermott et al., 2009). These researchers have highlighted the contribution of new knowledge from other actors to the innovation process.

Based on studies on the external environment, (McDermott, 2007) observed that regional contexts and institutional features significantly impact the development path of winemaking firms in Argentina. Similarly, sector-specific and national characteristics were found to be the reasons for the innovative and

competitive position of winemaking companies in Europe (France and Germany) and Australia (Aylward & Turpin, 2003; Hussain et al., 2007). Doloreux conducted a study that explored whether and how regional conditions affect innovation patterns within the Canadian wine industry. The findings revealed that, despite significant historical and territorial differences, firms innovate very similarly across three wine-producing regions (Ontario, British Columbia, and Quebec). As such, there are no variations in the wine industry's innovation based on distinct regional characteristics (Doloreux et al., 2015).

Although the wine industry is not considered high technology, many companies constantly innovate to meet customer demands by improving the product, productivity, commercial, and packaging (Toops, 2009). Process innovation in the wine industry primarily focuses on production and commercial methods (Aylward & Turpin, 2003; Dries et al., 2013), which can lead to lower costs, higher productivity levels, and better quality (Clarke, 2012). Innovations in the agricultural sector, such as smart farming and artificial intelligence, have been found to be critical to agricultural development (Budaev, 2018). The use of AI in smart farming can lead to a more precise approach to agriculture. The innovation process in the agricultural sector involves the implementation of new thinking models and various technological, managerial, and socioeconomic tools aimed at improving society's living standards sustainably. (Muscio et al., 2017) demonstrated a positive correlation between innovation and cooperation. Universities and scientists contribute to innovation in the wine industry by using new technologies and know-how (Giuliani et al., 2011).

Research shows that firms' innovation is influenced by their internal technological capabilities, interactions with other firms, institutions, research organizations, and government agencies, and regional characteristics (Edquist, 2006; Szeto, 2000; Tödtling & Trippl, 2004).

In sum, the literature on innovation in the wine industry indicates that various studies have been conducted on the topics of innovation, cooperation, region, and wine consumption. Nevertheless, there is a gap in the literature that investigates inclusive innovation in the craft industry, which emphasizes learning by doing, particularly in rural areas where marginalized groups reside. This research aims to examine how the craft industry conducts inclusive innovation in Nova Scotia, a developing rural region. Inclusive innovation theory was used to explore this question, and the "ladder of innovation" was utilized to assess the level of inclusivity of the craft industry in Nova Scotia.

Rural and agricultural innovation

Rural and agricultural innovation have been important in addressing the challenges facing farmers, including poverty, climate change, and food

insecurity. A number of studies have explored various approaches to promoting innovation in these sectors.

One approach is through collaboration and partnerships between different actors in the innovation process, as demonstrated in (Boza Martínez et al., 2021; Williams et al., 2022). (Boza Martínez et al., 2021) describe a collaborative agricultural extension program that was adopted under the triple helix model of innovation, which involves close collaboration between universities, government agencies, and private companies. Similarly, (Williams et al., 2022) explore a research-private sector partnership in Lombok, Indonesia, to promote agricultural innovation. Both studies highlight the importance of collaboration and partnerships for promoting innovation in the agricultural sector.

Another important factor in promoting agricultural innovation is the role of the state, as discussed in (Habiyaremye et al., 2020). The authors argue that the state can play a critical role in promoting innovation by creating an enabling environment through supportive policies, regulations, and infrastructure.

The role of on-farm experimentation in promoting innovation in agriculture is also highlighted in (Lacoste et al., 2022). The authors argue that on-farm experimentation can help farmers test new practices and technologies in a real-world setting, leading to more effective innovation.

Inclusive innovation in agricultural value chains is discussed in (Horton et al., 2022), who argue that an inclusive approach is needed to ensure that all actors in the value chain, including smallholder farmers, are included in the innovation process. They also highlight the importance of a systems approach to innovation, which involves considering the entire value chain and the interactions between different actors.

(Cofre-Bravo et al., 2019) explore the role of the farm workforce in promoting innovation in agriculture, highlighting the importance of farmers' innovative behavior and practices. They argue that understanding the role of the farm workforce in the innovation process is critical for promoting inclusive innovation.

Finally, (Ouma-Mugabe, 2016) discusses innovation systems approaches to agriculture and rural development, emphasizing the need for a holistic approach that considers the entire innovation system, including the interactions between different actors and institutions.

In summary, promoting innovation in rural and agricultural sectors requires collaboration and partnerships between different actors, an enabling policy and regulatory environment, on-farm experimentation, an inclusive approach to innovation, and a systems perspective on the innovation process. These findings have important implications for policymakers and practitioners seeking to promote innovation and development in these sectors.

Inclusive innovation

According to the (OECD/Eurostat, 2018), innovation refers to a new or enhanced product or process that differs significantly from the previous products or processes of a unit and has been made available to potential users or put into use by the unit. However, inclusive innovation scholars challenge the traditional firm-centric approach to measuring innovation. They extend the units of observation to include where and why innovation occurs, who is involved in the innovation process, what the results are, and who benefits from it (Schillo & Robinson, 2017).

Inclusive innovation, as defined by (Heeks et al., 2013), is the extension of new and existing technologies, products, and processes to marginalized populations who have been left behind by traditional innovation models. This approach emphasizes the need to reach out to underserved or excluded groups, including women, Indigenous people and the poor (Lorentzen, 2011), informal sector entrepreneurs (Heeks et al., 2014), and those affected by industrial or territorial boundaries or new technology (Planes-Satorra & Paunov, 2017).

(Heeks et al., 2014) identify two key issues for inclusive innovation. The first issue is identity, which involves identifying which groups have been historically marginalized, disenfranchised, or excluded and therefore need to be engaged in more inclusive innovation approaches. The second issue concerns the incorporation of target communities in aspects of innovation. To address this, Heeks et al. (2013, 2014) introduced a "ladder of inclusive innovation," which suggests that the target communities should be involved not only in the outcomes of innovation but also in the direction and process of inclusive innovation. This ladder consists of six levels of inclusion, including intention, consumption, impact, process, structure, and post-structure.

Inclusive innovation is defined as the means by which new goods and services are developed for the billions around the world living on lowest incomes (Foster & Heeks, 2013b). However, in this paper we define inclusive innovation involves organizations' ideation and knowledge discovery, product and process development, technology adoption and deployment, governance, and social participation activities with a broad spectrum of communities, users, and stakeholders that the organizations touch, including those who may be displaced by the innovation outcomes.

Structurally, developing innovation is the result of a network of dynamically linked actors within an institutional environment (Edquist, 2006). This system generates new knowledge through a continuous process of learning, searching, and exploring (Lundvall, 1992). Innovation systems describe how interactivity between system actors will orient innovation over time as relations and modes of learning change (Lundvall, 1992). A variety of learning categories are seen as contributing to innovation: learning by doing, in which individuals acquire

knowledge through production processes; learning by using, in which actors must adjust new technologies to fit specific tasks; and learning through interaction, in which actors work with each other to learn (Foster & Heeks, 2013b). With this definition craft industry which is tacit knowledge-based (Wood, 2009) is a system of innovation because it is learning by doing.

Inclusive innovation can take many forms, including participatory research and development, co-creation, open innovation, and social innovation (Gras et al., 2019). Collaboration among diverse actors, including governments, businesses, universities, and civil society organizations, is necessary to create and disseminate new technologies and solutions that benefit underrepresented communities (Danse et al., 2020). Inclusive business models, as elaborated by Danse et al. (2020), involve partnerships between firms, government, and civil society to develop innovative solutions for addressing social and environmental challenges. These models have the potential to promote sustainable and inclusive economic growth, particularly in base-of-the-pyramid (BOP) markets.

Inclusive innovation also involves partnerships and knowledge exchange to co-create innovation in living labs projects (Habiyaemye et al., 2020) and scaling innovation hubs for impact on knowledge, innovation, and entrepreneurial ecosystems (Mwantimwa et al., 2021). It requires operationalizing inclusive innovation through innovation platforms and multi-stakeholder processes in livestock value chains (Swaans et al., 2014) and transforming global agriculture through on-farm experimentation (Lacoste et al., 2022).

The promotion of inclusive innovation has become a priority in the field of agriculture. (Hall et al., 2001; Hall et al., 2003) emphasize the importance of research partnerships and institutional arrangements that facilitate collaboration between different actors in the innovation process, particularly those who may be excluded from traditional innovation systems. Similarly, (Herrero et al., 2021) argue that innovation in food systems can have significant positive impacts on a range of Sustainable Development Goals (SDGs), but must address trade-offs and ensure inclusivity and sustainability. (Mwantimwa et al., 2021) suggest that innovation hubs can facilitate the diffusion of innovation and knowledge, particularly in low-income settings, but face challenges in scaling up and becoming self-sustaining. (Williams et al., 2022) offer a case study of a research-private sector partnership in Lombok, Indonesia, highlighting the complexities and realities of such partnerships in promoting inclusive innovation.

Value chain upgrading is another way to promote inclusive innovation in agriculture. (Kilelu et al., 2017) reflect on the contributions of multi-stakeholder processes in dairy development in Tanzania, highlighting the role of value chain upgrading in including smallholders in markets. They argue that these processes can create new opportunities for smallholders while ensuring equitable distribution of benefits. (Swaans et al., 2014) draw on lessons from

innovation platforms in livestock value chains in India and Mozambique to suggest that such platforms can promote collaboration between actors and help overcome barriers to innovation adoption.

However, promoting inclusive innovation also poses challenges. (McCampbell et al., 2021; Opola et al., 2021) problematize the concept of inclusion, arguing that it can be used to justify existing power relations and reinforce marginalization. (McCampbell et al., 2021) suggest that a critical approach is needed to understand how inclusive innovation can perpetuate or challenge exclusion, while (Opola et al., 2021) highlight the need for greater collaboration between academics and practitioners to ensure that inclusive innovation narratives reflect the realities of marginalized populations.

(Cofre-Bravo et al., 2019) examined the role of the farm workforce in farmers' innovative behavior and the adoption of technology and practices on the farm, arguing that the farm workforce should be considered as a part of farmers' innovative behavior, and that inclusive innovation on the farm requires the participation of the workforce. (Danse et al., 2020) focused on inclusive business models for achieving food and nutrition security in BOP markets, proposing a framework that emphasizes collaboration between multiple stakeholders and contextual factors.

Overall, promoting inclusive innovation in agriculture requires the involvement of diverse stakeholders, the development of supportive institutions and policies, and a critical approach to understanding power relations and the realities of marginalized populations. Table 1 shows the summary of previous studies in this concept:

Article	Summary and insight to inclusive innovation	Region
(Cofre-Bravo et al., 2019)	This study explores the role of the farm workforce in farmers' innovative behavior and the adoption of technology and practices in agriculture. The study found that involving the farm workforce in the innovation process is a key factor in the adoption of technology and practices in agriculture. The authors suggest that this approach can lead to more inclusive on-farm processes and improved productivity.	Chile
(Danse et al.,	The research aims to identify the different inclusive business models (IBMs) that are effective in enhancing food and nutrition security in the bottom of the pyramid (BOP) markets. Insights gained from the research show that the IBMs in food and nutrition security are diverse, context-	N.A.

2020)	specific, and are dependent on the engagement of different actors, including consumers, producers, and other value chain actors.	
(Dries et al., 2013)	The research aims to explore the potential of open innovation in the Hungarian wine sector. Insights gained from the research show that open innovation can contribute to the development of new products and services, the improvement of existing products, and the creation of new market opportunities in the wine sector.	Hungary
(Foster & Heeks, 2013a)	The research aims to develop a conceptual framework that can guide the analysis of the diffusion of new technologies to low-income consumers. The framework is designed to be inclusive, incorporating the perspectives of both the supply and demand sides of innovation, and is based on the systems of innovation approach.	N.A.
(Habiyaemye et al., 2020)	The research examines the role of the state in fostering inclusive innovation for rural development, with a focus on South Africa. The study analyzes how government policies, regulations, and funding mechanisms can be designed to promote innovation that is accessible and beneficial for marginalized rural communities. The findings suggest that the state can play a critical role in facilitating inclusive innovation by creating an enabling environment, building innovation capacity, and ensuring that innovation benefits are shared equitably.	South Africa
(Heeks et al., 2013)	This paper provides a definition and conceptual framework for inclusive innovation, which refers to the development and dissemination of innovative products, services, and processes that benefit and empower marginalized populations. The study identifies key characteristics of inclusive innovation, such as affordability, accessibility, and user-centered design, and proposes a research agenda to advance the understanding and practice of inclusive innovation. The insights can be used by policymakers, practitioners, and researchers to guide the design and implementation of inclusive innovation initiatives.	N.A.

(Heeks et al., 2014)	This study explores new models of inclusive innovation that are emerging in developing countries, with a focus on how social and institutional factors shape innovation processes and outcomes. The research identifies several inclusive innovation models, such as frugal innovation, user innovation, and open innovation, and examines their potential to contribute to development goals. The study suggests that inclusive innovation can generate economic and social benefits for marginalized populations, but requires supportive policies, institutions, and partnerships.	Developing countries (multiple)
(Heeks et al., 2015)	This book expands on the research in the previous paper and provides a more comprehensive analysis of inclusive innovation for development. The book covers topics such as the drivers and barriers of inclusive innovation, the role of intermediaries and partnerships, and the measurement and evaluation of inclusive innovation outcomes. The study emphasizes the need for a holistic and collaborative approach to inclusive innovation that involves diverse stakeholders and addresses the broader social, economic, and environmental challenges.	Developing countries (multiple)
(Horton et al., 2022)	The research aims to understand how inclusive innovation in agricultural value chains can be achieved through a systems approach in diverse settings. The study highlights the need to consider the entire value chain and the different actors involved in it, including smallholders, processors, and retailers. It also emphasizes the importance of involving stakeholders in the innovation process to ensure the sustainability and effectiveness of inclusive innovation.	Bolivia, Ecuador, India, Kenya, and Peru
(Kruss, 2021)	The research examines the challenges of achieving inclusive innovation in South Africa and the need to build upgrading coalitions to promote inclusive development. The study argues that upgrading coalitions, which are partnerships between government, industry, and civil society, are essential for achieving inclusive innovation and promoting economic growth. The research emphasizes the need for	South Africa

	these coalitions to be inclusive, participatory, and accountable to ensure their effectiveness.	
(Kuramoto, 2014)	The research focuses on exploring inclusive innovation in Peru, which is a country with high levels of poverty and inequality. The study examines how the Peruvian government, civil society organizations, and the private sector work together to create an inclusive innovation ecosystem that benefits marginalized populations. The research findings highlight the importance of cross-sectoral partnerships and knowledge exchange in creating inclusive innovation. The study shows that inclusive innovation can play a crucial role in addressing social and economic challenges in low-income countries.	Peru
(Mapelli et al., 2016)	This research explores how the concept of inclusive innovation can be applied in the agri-food industry. It focuses on the case of Semi di Libertà, an Italian social enterprise that promotes the use of traditional seeds in organic agriculture. The study examines the role of partnerships in enabling inclusive innovation, particularly the collaboration between Semi di Libertà and its partners in the public sector, civil society organizations, and private companies. The research highlights the importance of trust, mutual learning, and shared values in building effective partnerships for inclusive innovation.	Italy
(McC Campbell et al., 2021)	This research problematizes the concept of inclusion and exclusion in the context of inclusive development and innovation. The study examines how different actors involved in inclusive innovation, such as policymakers, academics, and practitioners, understand and define these terms. The research findings highlight the diverse and often conflicting perspectives on inclusion and exclusion, which can result in tensions and challenges in implementing inclusive innovation initiatives. The study emphasizes the importance of engaging in reflexive and critical dialogue to enhance understanding and promote more inclusive practices.	

(Opola et al., 2021)	This research investigates the hybrid nature of inclusive innovation narratives, which are influenced by both theoretical frameworks and practical experiences. The study focuses on the case of inclusive innovation in Kenya, examining how different actors involved in inclusive innovation, such as policymakers, NGOs, and private companies, frame and interpret the concept of inclusive innovation. The research findings highlight the need for a more nuanced understanding of the multiple and diverse perspectives on inclusive innovation, which can inform the development of more effective and context-specific policies and practices.	Kenya
(Paunov & Satorra, 2017)	This paper analyzes various inclusive innovation policies across the globe through international case studies. The authors aim to identify the common features of successful policies and provide insights into how inclusive innovation can be fostered in different contexts. The study highlights the importance of cross-sector collaboration and the involvement of marginalized communities in the innovation process.	
(Peerally et al., 2019)	This research examines the role of technological capability-building in promoting inclusive innovation through a case study of Grameen Danone Foods Limited, a social business in Bangladesh. The authors argue that technological capability-building can facilitate the development of inclusive innovation by improving the skills of individuals and organizations to generate and implement new ideas.	Bangladesh
(Petersen et al., 2018)	This research examines the role of innovation capacity-building in promoting inclusive development in informal settings in South Africa and Malawi. The authors argue that interactive learning spaces, such as Fab Labs and Living Labs, can facilitate the development of innovation skills and enhance the participation of marginalized groups in the innovation process. The study provides insights into the potential of these learning spaces to promote inclusive innovation and development.	South Africa and Malawi.

(Planes-Satorra & Paunov, 2017)	This research analyzes the role of inclusive innovation policies in promoting innovation that benefits marginalized groups through a series of international case studies. The authors argue that such policies can promote social and economic development by involving a broader range of stakeholders in the innovation process. The study provides insights into the design and implementation of effective inclusive innovation policies.	
(Schillo & Robinson, 2017)	This research examines the concept of inclusive innovation in developed countries. The authors argue that inclusive innovation can promote social and economic development by addressing the needs of marginalized groups. The study provides insights into the characteristics of inclusive innovation in developed countries and the potential barriers to its implementation.	
(Swaans et al., 2014)	This research examines the role of innovation platforms in promoting inclusive innovation in livestock value chains in India and Mozambique. The authors argue that innovation platforms can facilitate the development of inclusive innovation by promoting collaboration and knowledge exchange among stakeholders. The study provides insights into the potential of innovation platforms to promote inclusive innovation in the agricultural sector.	India and Mozambique.
(Theodosiou et al., 2012)	This research investigates the relationship between strategic orientations, marketing capabilities, and firm performance in service organizations. The authors argue that firms that develop strong marketing capabilities and have a customer-oriented strategic orientation are more likely to achieve high performance. The study provides insights into the importance of customer-centric approaches in promoting inclusive innovation in service organizations.	
(Usup et al., 2020)	this research examines the role of value innovation capabilities, market orientation, and social capital in improving the performance of Central Kalimantan Bank in Indonesia. The authors argue that firms that develop strong value innovation capabilities and have a customer-oriented market	Indonesia

	orientation and high social capital are more likely to achieve high performance. The study provides insights into the potential of value innovation capabilities to promote inclusive innovation in the banking sector.	

Methodology

This research uses a qualitative design by running semi-structured interviews. The process of designing a qualitative interview in this research was a series of stages ranging from the determination of research topics, conversation issues, and other aspects of the interview session to the selection of interviewees and other preparations (Valles, 2014).

Setting

This research was conducted in the summer of 2022. The interview guide of this study starts with general questions and patch creation which includes asking questions about wineries' main activities and innovations. The next section is in terms of their product and processes. Questions regarding the innovation and impact are also included in the questionnaire. We chose the semi-structured interview approach, as it provides us with the freedom to adapt interview questions as new knowledge emerges from interviews (Gillham, 2005).

Eight months of empirical work were undertaken in rural Nova Scotia. After conducting online research on all of Nova Scotia's wineries, we completed a database containing the key characteristics of each winery, and include winery location, years of operation, ownership/workforce structure, owner demographics, and contact details. We invited the owner or master winemaker for a semi-structured interview lasting 45–60 minutes. Interviews were conducted in person and they were recorded. We conducted the interviews to the sample of wineries in Nova Scotia with commercial operations. When identifying the persons to be interviewed, we considered those who met the following selection criteria: they possessed the relevant information; they were physically and socially accessible; they were willing to provide information, and they were able to communicate the information accurately (Gorden, 1998).

For reasons of time and opportunity, for this paper we worked with a sub-sample of five winemakers and winery owners. We selected this sub-sample according to those specific individuals who have experienced the phenomenon can be enough to identify the core elements (Starks & Brown Trinidad, 2007).

Table 2 indicates the sub-sample of the interviews that were conducted and the sub-region of locations in Nova Scotia.

Table2-Interviewees' descriptive table

NO.	Numberof interviewees in the interviews meeting	Interviewee's gender	Location
1	1	Male	Falmouth
2	1	Male	Grand Pré Rd
3	1	Male	Wolfville
4	2	Male and Female (Couple)	Wolfville
5	1	Male	Bear River

To obtain quality information and to take care of ethical aspects, we ensured the following: An informed consent form was sent to the interviewees to explain to the interviewee the purpose of the research, as well as to inform him/her about the interviewer; informed consent was requested, guaranteeing confidentiality; and permission was requested to record the conversation, and take photos.

Interviews were digitally recorded and were conducted at the relevant winery either in an office in the production facility, or in the farm. All interviewees were males, except one who was a couple. Recorded files were transcribed using Trint, and then all transcripts were manually verified to spot for potential errors and to edit errors. The text was coded using Nvivo, and Thematic analysis was adopted to analyze the data. See Fig. 3 above that presents the steps of inclusive innovation that were used to code the interviews for this study.

Data collection and analysis

Our empirical data comprise five semi-structured interviews with winery owners or winemakers in Nova Scotia. In 1980, Nova Scotia's first winery opened, and the industry has grown rapidly since then. Currently, Nova Scotia is home to more than 20 wineries. The climate in Nova Scotia (NS) is cooler, and the growing season is shorter than in many other winegrowing regions (Wines of Nova Scotia, 2016).

There are now more than 400 wineries throughout Canada that allow for wine production that significantly impacts regional, provincial and national economies. Nova Scotia has a small but continuing to grow and evolve wine industry, now having over 20 different wineries in the province (statista.com, 2021). Considering the GDP by the industry and comparing it with the rest of Canada (figure 1 above) we found Nova Scotia craft industry underperformed. So, this region can make a good case for use to study inclusive innovation.

The focus of data analysis was the determination of the perception of inclusiveness. Data were coded by using the qualitative data analysis software Nvivo. Following an iterative process, codes were revisited and refined throughout the analysis process. There are two primary ways in thematic analysis for the identification of themes within data. One can take either

conduct an inductive or "bottom-up" approach or a theoretical or deductive approach (Hayes, 2013). In distinguishing between the two approaches (Braun & Clarke, 2006) characterized an inductive approach as one where the coding of the data is data-driven and does not try to fit it into a preexisting coding frame, while a deductive/theoretical approach is one that is driven by the researcher's theoretical or analytic interest in the area. As in this research, we had a preexisting framework defined by (Heeks et al., 2013), we employed a deductive analysis approach. However, as we went through the interviews we found specific inclusive innovation concepts, following an inductive approach.

We carried out the data analysis in three main stages. First, we developed a set of narratives that described the inclusive innovation processes associated with issues that arose in all five wineries. Second, we identified issue domains in which winemakers and winery owners engaged in inclusiveness. In the third stage, we focused on answering our research question, and identifying the points that make the craft industry innovation inclusiveness. We began by focusing on the interviewees' experiences of inclusiveness and how excluded concepts are related to the craft industry. We found 33 first-order concepts capturing this view. We grouped similar first-order concepts together, identifying second-order themes that more parsimoniously described the understandings, feelings, and actions we had coded (Gioia et al., 2013). We then chose labels for the same themes, which made the third-level codes which is the inclusive perspective we have identified.

Table 3 below illustrates the coding process:

Illustrative 1st Order concepts	Illustrative 2nd Order themes	Final dimension
If 50,000 people come here, I can assure you that people will start putting their houses in Airbnb.	Impact of the craft industry on the revitalization of rural area	
If we buy grapes from a great borrower, which we do, we buy over \$1,000,000 in burgers from neighbors.		
We also so line to the local community. So the community is benefiting because they're getting a good product. They're getting wine for their dinner table or for their functions.		

It impacts local accommodation. It impacts all the stores in Wolfville. People come here, they're staying for a few days, not just for an afternoon. They sleep. They eat. They shop. They tour. Local tour companies have started. They can take small groups and bring them to all the wineries we have bus tours are coming up now.		Inclusive impact
We collaborate with government. If they're looking for wineries to travel somewhere else, to have receptions to represent the province, we try to be there for that.	Branding the rural craft industry	
They're going to go and visit distilleries and breweries and wineries and jewelry stores and little souvenir shops, and it's just the spillover to HST.	The economic impact of the craft industry on the rural area	
The wineries selling all their products and hiring locally. I think that's a huge impact on the local economy.	Impacts on employment	
Some have graduated from the University of Mendoza. Some have graduated from Washington state .	People graduated from different universities as a source of knowledge for the business	Inclusive knowledge
A couple of years ago I had a wonderful student, Ruth Njagi, from South Africa,		
He grew in Montreal, so, he has Canadian citizenship. Then he moved to California and Argentina then, back to the Nova Scotia. The Jost family moved here from Germany in the 1970s, and they came from Rhine region. They came from the Rhine Hassan, so on the Rhine River and we're coming here to do something different.	People who grew up in another region with different experiences as a source of knowledge for the business	
In Tidal Bay is a group of you who are always a great ambassador of the idea are involved because there is that idea of collaboration.	Process of making a product through cocreation and collaboration in	

And I think there are six or seven founding members of the Tidal Bay that all the wineries got together.	which local wineries were engaged with the purpose of having a local unique product which contribute to the rural region	Inclusive process
It's a collective project. I certainly would never want to speak of the first person, even on behalf of Benjamin Bridge and as it relates to Tidal Bay, because it is a genuinely collective project.		
We're very collaborative and that's something that comes from theory. We understood profoundly the benefits of collaboration and unity and thought nothing good out of conflict.	Collaboration contribution	
I think in an industry that's growing, collaboration is good because you need to get your voice out there. Tidal Bay is a great example. I love telling the story about Tidal Bay, which kind of it's kind of off topic a bit.		
It's a beautiful product. It is so popular. So, I think that's innovation.	The output of collaboration is an innovative product	
3,000 years of kind of like symbiotic interactions that the Mi'kmaq had with this particular piece of land, and the last 50 years, they were interventionist to the extent of replacing Indigenous flora by European genetic variety because that is how the wine of the motherland must taste	Staying with the natural taste of wine in order to include Indigenous people and their practices	
We don't add any yeast, any nutritious, any fermentation, any sulfites, just the wine going through indigenous fermentation, unprompted, using the indigenous seeds that is native to the ecosystem and going through that self-regulated process on their own		

Impact

When an innovation benefits the excluded group, it is inclusive. It is possible to understand that positive impact in different ways. According to a more quantitative economic perspective, this can be measured in terms of greater productivity, welfare, and utility (Heeks et al., 2013).

Respondent1 (Res1), Respondent2 (Res2), and Respondent3 (Res3) highlighted the impact of the craft industry on Nova Scotia. They described how the craft industry could have an impact on the rural community by creating opportunities for restaurants and houses. They believe this industry can attract tourists and conduct local tour companies in the province. Even the local economy will gain benefits by selling their products as a souvenir. So, the craft industry can develop rural communities, and this excluded group can gain benefits. Res2 clearly describes this issues:

"one day, they're going to have to sleep somewhere. And if they sleep somewhere, they're going to have to eat. And then they want to travel during the day. They want to see things. So, they're going to go and visit distilleries and breweries and wineries and jewelry stores and little souvenir shops."

Process

The innovation is inclusive if it includes members of the excluded group in its development. The entire group may not be able to participate, so this immediately shrinks down to "members of the excluded group" (Heeks et al., 2013).

We found three main themes in this regard:

One theme was about indigenous people and practices. It was about the process of making a product with the taste of the motherland and indigenous context. Respondents indicated that their wine does not have any additional to stick with indigenous taste. Indigenous peoples have inherited and practiced cultures and ways of relating to people and the environment that are unique to them. Despite living in dominant societies, they have retained distinct social, cultural, economic, and political characteristics (Poliandri, 2011). Res1 pointed out how they stick with indigenous practice:

"We don't add any yeast, any nutritious, any fermentation, any sulfites, just the wine going through indigenous fermentation, unprompted, using the indigenous seeds that is native to the ecosystem and going through that self-regulated process on their own"

The other themes were found in this dimension were about collaboration and cocreation of a product that is an innovative output and it can contribute to the development of the rural area. Tidal Bay, the province's trademark wine, is known for its white wines. Wines from Tidal Bay are known for their acidity,

crispness, and freshness. White wine grapes flourish in Nova Scotia's terroir with the cooler climate. The acidity in the grapes is preserved and contributes to the desirable crisp and acidic character (Wines of Nova Scotia, 2016). As the wine industry expands in NS, winemakers are becoming more aware of the terroir of NS, which makes quality red wine grapes difficult to grow. The findings from interviews show that this product is created through the cocreation process, and the excluded group has been involved in creating it. Interviews showed that to create this product, local wineries and Nova Scotia association collaborated, and they finally produced it through co-creation. Res 1 mentioned that:

"Everything about Tidal Bay is a group of you are always great ambassadors of the idea because there is that idea of collaboration. We love coming together as a collective. It's very intuitive and attractive to us as a proposition that we love. But then also stylistically, Tidal Bay will be the fit. So that also kind of matches kind of our approach to things where the style itself has roots and connection to what we can do at the highest level. And so that would be a great example. It's an appellation. It's something that is inspired, perhaps more so, by the European model as well. And we're really honored to just be participants in the creation of a kind of like that."

Knowledge

Our findings show participants talk about their employees with different backgrounds. This diversity was either because of their university or the place they grew up. There are people who graduated from African universities or US universities. There are indigenes and local people and foreign international people. This diversity contributes to knowledge. In this regard, we can consider there is inclusive knowledge in this industry. All the participants highlighted their employees' diversity. For example, Res 5 mentioned:

"I had the odd student from King's TEC in Assisi, in Campo. They have a vineyard training program and a winemaking program. I have worked with some of the students from there and very well-trained people. And. Yeah, and so that and so. I always have extra help that way."

This participant added that :

"And a couple of years ago, I had a wonderful student, Ruth Njagi, from South Africa, and she was studying there, and I needed some help for harvest. So, she came on board from there and was a wonderful person. We worked very well together. So we went through a harvest together, and I told her later that some of the wines that she helped me make one some awards. So, she was very happy about that. "

This diversity of knowledge and background proves that innovation is inclusive because knowledge is inclusive.

Discussion

In this research, we employed an inclusive innovation lens and referred to the inclusive innovation ladder defined by (Heeks et al., 2013), and we found how inclusive innovation is conducted in the craft industry in Nova Scotia. This research question is identified as a gap in innovation literature, specifically in the craft industry, a tacit-based knowledge industry. We found the innovation inclusiveness in Nova Scotia with a rural spirit. In this definition, this study contributes to the ladder of inclusive innovation defined by (Heeks et al., 2013) by a discussion regarding industry-specific inclusive elements, including process, impact, and knowledge.

Conclusion

A number of scholars have pointed out the dynamism and complexity of global markets in the Food & Beverage sector, particularly when the wine industry is considered (Anderson & Nelgen, 2011). Wine markets have become more competitive as a result of globalization (Giuliani, 2011). The firms that invest in innovation and cost reduction are usually more competitive in this new competitive landscape.

Although there have been many valuable studies on the craft industry, a review of the literature shows that many of these studies focus more on process and consumption, and region (B. Rinaldo et al., 2014; Barisan et al., 2015; McDermott, 2007). Less attention is paid to this industry from an inclusive innovation point of view.

In developing regions, a new form of innovation is emerging. It has different names reflecting different emphases: "inclusive innovation", "pro-poor innovation", "belowtheradar innovation", "BoP [bottom of the pyramid] innovation", etc. (Foster & Heeks, 2013). In a system of innovation, the interdependence between system actors is described, with particular attention to changing relations and modes of learning within a system over time (Lundvall, 1992). A variety of learning categories are seen to emerge during innovation: learning by doing, learning by - using, and learning by interaction. The craft industry is a tacit knowledge based on learning by doing (Wood, 2009). So, it is considered a system of innovation.

We found a gap in the literature in terms of studying the inclusiveness of the craft industry in an underperformed region like Nova Scotia with a rural spirit. This study aims to provide a relevant framework to help organizations and policymakers to find more details about the inclusiveness of the craft industry in Nova Scotia. Then the main objective of this study can be defined as assessing the state of inclusiveness of the craft industry in Nova Scotia.

To address this gap, we employed a qualitative methodology and ran semi-structured interviews with winemakers and winery owners. The results were

coded using an inductive-deductive approach and referring to the preexisting framework introduced by (Heeks et al., 2013). In this study, we contribute to the discussion of the elements of the ladder of inclusive innovation, described by (Heeks et al., 2013), relating to inclusion in terms of process, impact, and inclusive knowledge provided by the industry, in particular. A key contribution from this study for practitioners is the need to introduce inclusive sources of businesses to develop scalable and effective initiatives for inclusive development.

Research Limitations and future directions

Although this study brought valuable findings and contributed to the literature, there are still limitations. Firstly, this study includes a sub-sample of the complete list of interviews, and future research can be conducted with the full sample and interviews with other partners in this industry. This research had a deductive approach and used a preexisting model. Future research can be done more inductively and with the possibility of finding other steps in the ladder. Another direction for future research is running the research in another industry or another region and comparing the result with current research.

References

- Al-Qdah, M. S., & Salim, J. (2013). A Conceptual Framework for Managing Tacit Knowledge through ICT Perspective. *Procedia Technology*, 11, 1188-1194. <https://doi.org/https://doi.org/10.1016/j.protcy.2013.12.312>
- Anderson, K., & Nelgen, S. (2011). Wine's Globalization: New Opportunities, New Challenges. <https://EconPapers.repec.org/RePEc:adl:winewp:2011-01>
- Arocena, R., & Sutz, J. (2000). Looking at National System of Innovation from the South. *Industry & Innovation*, 7, 55-75. <https://doi.org/10.1080/13662710050030303>
- Aylward, D., & Turpin, T. (2003). New Wine in Old Bottles: A Case Study of Innovation Territories in "New World" Wine Production. *International Journal of Innovation Management*, 07, 501-525.
- B. Rinaldo, S., F. Duhan, D., Trela, B., Dodd, T., & Velikova, N. (2014). Evaluating tastes and aromas of wine: a peek inside the "black box". *International Journal of Wine Business Research*, 26(3), 208-223. <https://doi.org/10.1108/IJWBR-06-2013-0022>
- Balaguer, A. (2008). The rise and growth of a policy driven economy: Taiwan. *Small Country Innovation Systems*
- Barisan, L., Boatto, V., Rossetto, L., & Salmaso, L. (2015). The knowledge of Italian wines on export markets A nonparametric methodology to analyze promotional actions. *British Food Journal*, 117, 117-135. <https://doi.org/10.1108/BFJ-07-2013-0192>
- Bigliardi, B., & Galati, F. (2013). Innovation trends in the food industry: The case of functional foods. *Trends in Food Science & Technology*, 31, 118-129. <https://doi.org/10.1016/j.tifs.2013.03.006>
- Board, F. a. T. (2021). GDP by industry.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77-101.
- Budaev, D., Lada, A., Simonova, E., Skobelev, P., Travin, V., O.Yalovenko, . . . A.Zhilyaev. . (2018). Conceptual design of smart farming solution for precise agriculture. *International Journal of Design & Nature and Ecodynamics*, 13(3), 307-314.
- Clarke, D. W., Perry, P. and Denson, H. . (2012). The sensory retail environment of small fashion boutiques. *Journal of Fashion Marketing and Management* , Vol. 6 No. 4, pp. 492-510.
- Doloreux, D., & Lord-Tarte, E. (2014). Innovation in the Canadian Wine Industry: Evidence from Three Wine-Producing Regions. *European Planning Studies*, 22(5), 1062-1080. <https://doi.org/10.1080/09654313.2012.758689>
- Edquist, C. (2006). Systems of Innovation: Perspectives and Challenges. In (pp. 181-208). <https://doi.org/10.1093/oxfordhb/9780199286805.003.0007>
- Foster, C., & Heeks, R. (2013). Conceptualising Inclusive Innovation: Modifying Systems of Innovation Frameworks to Understand Diffusion of New

- Technology to Low-Income Consumers. *European Journal of Development Research*, 25. <https://doi.org/10.1057/ejdr.2013.7>
- foundation, C. r. r. (2021). State of Rural Canada -Opportunities, Recovery & Resiliency in Changing Times- NOVA SCOTI
- Gillham, B. (2005). *Research Interviewing: The range of techniques: A practical guide*. McGraw-Hill Education (UK).
- Gioia, D., Corley, K., & Hamilton, A. (2013). Seeking Qualitative Rigor in Inductive Research. *Organizational Research Methods*, 16, 15-31. <https://doi.org/10.1177/1094428112452151>
- Giuliani, E., Morrison, A., & Rabellotti, R. (2011). Innovation and technological catch-up: The changing geography of wine production. <https://doi.org/10.4337/9780857930514>
- Giuliani, E., Morrison, A., Rabellotti, R. (Eds.). (2011). *Innovation and technological catch-up: The changing geography of wine production*. Edward Elgar Publishing.
- Gorden, R. (1998). *Basic Interviewing Skills*; . Waveland Press Inc.: Long Grove, IL.
- Hayes, N. (2013). Theory-led thematic analysis: social identification in small companies. In *Doing qualitative analysis in psychology* (pp. 93-114). Psychology Press.
- Heeks, R., Amalia, M., Kintu, R., & Shah, N. (2013). Inclusive innovation: definition, conceptualisation and future research priorities. development informatics working paper(53).
- Hussain, M., Cholette, S., & Castaldi, R. (2007). Determinants of wine consumption of US consumers: An econometric analysis. *International Journal of Wine Business Research*, 19, 49-62. <https://doi.org/10.1108/17511060710740343>
- Jantzi, H. A., & McSweeney, M. B. (2019). An overview of wine consumers in Nova Scotia, Canada: A conjoint analysis study. *Journal of Wine Research*, 30(1), 48-61.
- Lundvall, B. A. (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*.
- Lundvall, B. A. (2007). Higher education, innovation and economic development World Bank's Regional Bank Conference on Development Economics, Beijing, January, pp. 16-17
- McDermott, G. (2007). The Politics of Institutional Renovation and Economic Upgrading: Recombining the Vines That Bind in Argentina. *Politics & Society - POLIT SOC*, 35, 103-144. <https://doi.org/10.1177/0032329206297185>
- McDermott, G. A., Corredoira, R. A., & Kruse, G. (2009). Public-Private Institutions as Catalysts of Upgrading in Emerging Market Societies. *The Academy of Management Journal*, 52(6), 1270- 1296. <http://www.jstor.org/stable/40390369>
- Murray, R. A., & Wright, B. (2004). *The tangled vine: winegrowing in Nova Scotia*. Bridgewater, NS: Blue Frog.
- Muscio, A., Nardone, G., & Stasi, A. (2017). How does the search for knowledge drive firms' eco- innovation? Evidence from the wine industry. *Industry and Innovation*, 24(3), 298-320. <https://doi.org/10.1080/13662716.2016.1224707>

- NS-wine-association. (2019). Wine of Nova Scotia. <https://winesofnovascotia.ca/were-growing-nova-scotia/>
- NS. (2016). Nova Scotia. (2016). Targeted investments in Nova Scotia's wine sector. <https://novascotia.ca/news/release/?id=20160505002>
- OECD/Eurostat. (2018). Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition, The Measurement of Scientific, Technological and Innovation Activities. OECD Publishing, Paris/Eurostat, Luxembourg.
- Poliandri, S. (2011). First Nations, identity, and reserve life: The Mi'kmaq of Nova Scotia. U of Nebraska Press.
- Presenza, A., Abbate, T., Meleddu, M., & Cesaroni, F. (2016). Small- and medium-scale Italian winemaking companies facing the open innovation challenge. *International Small Business Journal*, 35(3), 327-348. <https://doi.org/10.1177/0266242616664798>
- Rimerman, F., & Eyler, R. (2013). The Economic Impact of the Wine and Grape Industry in Canada 2011-Canada's Wine Economy-Ripe, Robust, Remarkable. St. Helena, California, US: Wine Business Center.
- Schillo, R. S., & Robinson, R. (2017). Inclusive Innovation in Developed Countries: The Who, What, Why, and How. *Technology Innovation Management Review*, 7, 34-46. <https://doi.org/10.22215/timreview/1089>
- Starks, H., & Brown Trinidad, S. (2007). Choose your method: A comparison of phenomenology, discourse analysis, and grounded theory. *Qualitative health research*, 17(10), 1372-1380. [statista.com. \(2021\).](https://doi.org/10.1177/1049731507308499)
- Szeto, E. (2000). Innovation capacity: Working towards a mechanism for improving innovation within an inter-organizational network. *The TQM Magazine*, 12, 149-158. <https://doi.org/10.1108/09544780010318415>
- Tödtling, F., & Trippl, M. (2004). One size fits all? Towards a differentiated policy approach with respect to regional innovation systems.
- Toops, D. (2009). "Top selling new food products of 2008", available at: www.foodprocessing.com/articles/2009/top_selling_food_products_of_2008.html?page=1 (accessed 29 April, 2009).
- Tsai, K.-H. (2004). The Impact of Technological Capability on Firm Performance in Taiwan's Electronics Industry. *The Journal of High Technology Management Research*, 15, 183-195. <https://doi.org/10.1016/j.hitech.2004.03.002>
- Valles, M. (2014). Entrevistas Cualitativas. CIS-Centro de Investigaciones Sociológicas.
- Wine, T., & Association, G. G. (2016). Texas Wine Industry Facts. Retrieved on April, 7, 2016. Wines of Nova Scotia. (2016).
- Winter, S. G. (1987). Knowledge and Competence as Strategic Assets.
- Wolfe, D. A. (2009). Introduction: Embedded Clusters in the Global Economy. *European Planning Studies*, 17(2), 179-187. <https://doi.org/10.1080/09654310802553407>
- Wood, N., Rust, C., & Horne, G. . (2009). A tacit understanding: The designer's role in capturing and passing on the skilled knowledge of master craftsmen. *International Journal of Design*, 3(3), 65- 78

Incubators and Technology Parks and Sustainable Local Development: Analytical Framework and Evidence in Brazil

Marcelo Matos, Maria Cecilia Lustosa, Pedro Rocha

Larissa Almeida, Bruna Moll

Federal University of Rio de Janeiro, Brazil

Abstract

The present work departs from the conceptual framework of Local Innovation and Production Systems (LIPS) and their potential convergences with the perspective of sustainability to build a methodological framework for the evaluation of incubators, accelerators and technological parks (IATP) under the point of view of their contribution to an effectively sustainable regional and local development. It considers their adherence to the characteristics of the territory, the articulation to the local innovation system in a broad sense and the knowledge generation and diffusion processes with ample impact on local actors, as well as incentive structures and direct support for incubated and supported firms to mobilize competences for the solution of challenges of local society. This framework has been applied for surveying IATPs in Brazil. The results show that there is plenty of room for improvement, once only about one third of organizations engage in key activities connected to local sustainable development. But they also show surprisingly diverse and rich experiences that illuminate how these organizations can become players in an innovation system directed towards solving the main problems of society, contributing to an effectively sustainable development.

Key Words: Accelerators and Technological Parks; Local Innovation and Production Systems (LIPS); Sustainable Local Development

1. Introduction

The present work departs from the conceptual framework of Local Innovation and Production Systems (LIPS) and their potential convergences with the perspective of sustainability to build a methodological framework for the evaluation of incubators, accelerators and technological parks (IATP) under the point of view of their contribution to an effectively sustainable regional and local development. The present study seeks to offer a direct and objective contribution to policy organizations. Brazil has a National Programme for the Support of Innovative Environments (PNI), run by the Ministry of Science, Technology and Innovation, which explicitly states that IATPs are instruments for the promotion of regional and local development. Thus, it represents a rich interface between two public policy fronts which often do not dialog: STI and territorial development.

The allocation of public resources to these organizations is done through calls for proposals, which adopt a set of objective criteria for evaluating and ranking applicants. The organizations that score best according to certain criteria tend to access a greater volume of support resources, contributing to their development. Therefore, underlying this evaluation system is an incentive structure, which guides the strategies of these organisations in certain directions, eventually to the detriment of others. It is therefore crucial for the quality of public policy to build an evaluation system that generates the right incentives, aligned with the strategic objectives that the policy has. In fact, the policy to support IATPs in Brazil and in several countries has been limited to a set of evaluation criteria inspired by a very limited perspective of the role of these organisations in the territory and centred on indicators derived from the linear perspective of innovation.

Thus, this article presents the result of an effort to construct and apply an evaluation system for IATPs that places systemic territorial sustainable development at its centre.

Section 1 recovers the main elements of the conceptual framework that guides this study. Section 2 presents the methodological procedures of the study. Section 3 presents the main results obtained in the three surveys conducted with incubators, accelerators and technological parks. The conclusion reflects on the results and discusses to what extent the evaluation system built meets the proposed objective.

1. Conceptual Framework

1.1. Territorial Development and Local Innovation and Production Systems

The debate on development in political and academic circles underwent a redirection in the early 1990s, when it moved away from the sectoral/regional approach to focus on the local/territorial one (Amaral Filho 2001). Based on this territorial focus, new theories on local development emerged (Carrière and Cazella 2006). In studies on territorial dynamics of development, two main elements should be considered: first, that territories can acquire differentiating advantages resulting from the generation and maintenance of specific intangible resources; second, that the proximity relations and the specificities of the interactions of social actors in the local context are part of the territory building process (Vieira et al. 2006).

From this perspective, the construction of the conceptual and methodological framework of Local Innovation and Production Systems (LIPS), developed by RedeSist¹ stands out. This framework elaborates on a broad perspective of innovation systems (Freeman 1982, 1987; Lundvall 1985; Lundvall 2007; Cassiolato et al. 2014; Dutrenit and Sutz 2017) and suggests that any productive structure, in any territory, presents elements of articulation along productive systems, connections with educational institutions, research and technological diffusion and circulation of knowledge, deserving, therefore, to be considered from a systemic perspective (Cassiolato and Lastres, 1999; Cassiolato et al, 2003; Matos et al. 2017).

However, the great challenge on which this approach focuses, and which differentiates it from formulations often taken as analogous, is the broadening of the scope of relevant actors in the institutional and political construction of the territory, illuminating, in normative perspective, the importance of building strategies and public policies from local actors and with their protagonism in the implementation. From this perspective, local development is understood as a systemic phenomenon, determined by the relationships established among the most varied players in the territory (Lastres et al. 2004; Cassiolato and Lastres 2005, 2008).

The LIPSs framework has contributed to the understanding of the fundamental role that the territorial dimension has for the perspective of innovation systems. First, the learning process, through which companies and other actors build their capacities, is essentially interactive and social, mediated by different forms of proximity, identity and trust. Second, this interactive and social character is reinforced in the case of innovative efforts, given the need to identify and articulate complementary competencies and reduce the degree of uncertainty. Third, a fundamental part of the knowledge is tacit in nature and, therefore, can

only be appropriated through direct interaction. These characteristics add to other specificities of the territory, in terms of its physical, social, cultural and environmental characteristics, contributing for differentials of local productive and innovative structures associated with the concept of territorialization (Storper, 1997; Cassiolato and Lastres 1999; Cassiolato et al. 2003; Matos et al. 2017).

The LIPs framework is considered as an appropriate tool for analysing the territory from the perspective of sustainability (Lustosa et al. 2017; Podcameni et al. 2019). In the following section, we discuss the converging points between the frameworks of LIPs and of sustainability.

1.2. Local Sustainable Development

The theoretical framework of sustainability that was used in this research is based on Sachs (2009), who builds upon the concept of Ecodevelopment. This concept is based on the recognition of the interdependence of multiple processes related to the economic, social and environmental crises, such as: pollution, loss of biological and cultural diversity, climate change, disorderly urban growth, social exclusion and increased social inequality (Vieira 2003).

The 2030 agenda offers ways for achieving systemic sustainable development. The Sustainable Development Goals (SDGs) converges with the Ecodevelopment perspective since both underline the need for the reconfiguration of the global economic system as a prerequisite for sustainability, reinforcing the need to have a holistic perspective of society's problems, not limiting the analysis to the management of natural resources. Sachs (2009) established the following dimensions of sustainability: Social, Cultural, Ecological, Environmental, Territorial, Economic, National Political and International Political.

This approach constitutes, therefore, the main reference in the search for new analytical perspectives to evaluate the socio-environmental impacts of Local Innovation and Production Systems. Lustosa et al. (2017) and Podcameni et al. (2019) discuss the several points of convergence between the ecodevelopment approach and LIPs framework.

The first point of convergence is associated with the spatial dimension. From both perspectives, the physical space constitutes the background that defines the territorial specificities according to its geographical characteristics. The occupation of this space by people is permeated by the ecosystem, which is present in each and every territorial construct, which defines its specific characteristics. At the same time, the evolution of the territory generates repercussions on nature, altering it and conferring specificities arising from the local dimension.

The second point of convergence is the systemic perspective. Both LIPSs and the environment presuppose the articulation of diverse constitutive elements with routinized interactions, determining their own internal dynamics. The importance of local players and their strategies, the specific characteristics of the biomes, as well as the formal and informal institutions is emphasized, outlining the dispute inherent to the environmental agenda and pointing out the interest groups around (environmental) conflicts. Thus, the mediation of these groups and the consequent unfolding of socio- ecological systems is an important dimension of analysis. The ability of these complex systems to exist over time, reproducing structures in order to enable their existence and growth in the future converges with the broad notion of sustainability.

Third, both highlight the role of power structure and mediation processes. The clash between economic, political and social forces determine the unequal access to (natural) resources, the asymmetric appropriation of results and prioritizes certain technological paths to the detriment of others.

The fourth point of convergence, lies in the multiescalar perspective. Both LIPS and local socio- environmental systems establish interfaces at regional, national and global levels. In the articulation between the local and the global spheres they emphasise the pressure the globalisation process exerts on local territories. But the local sphere is also a source of resilience in relation to globalizing pressures and the locus of manifestation of cultural and historical specificities (Cassiolato et al. 2015).

Therefore, this research mobilizes this multiscale, systemic and dynamic perspective to discuss how a specific set of players, namely incubators, accelerators and technology parks, articulate with the other players of the innovation system and might contribute to sustainable local development.

1.3. S&T Organizations for Local Sustainable Development

Traditional literature suggests that IATPs can contribute to the strengthening of "innovation ecosystems" by encouraging competitive or cooperative interaction between the actors, once the presence of institutions that mediate relations and proximity between them facilitate the diffusion of "artefacts" (e.g. technologies, products, processes), information and knowledge (Allen 1988, Mian 1996, OECD 1997, Bergek and Norrman 2008, Mian et al. 2012; 2016, Etzkowitz 2002, Oliveira et.al. 2017).

We consider the concept of innovation ecosystems not to be adequate for addressing the objectives of the present research. It lacks a rigorous conceptual basis and is usually associated with a waring subset of social actors directly linked to productive, scientific, technological and innovative activities. However, this analysis requires a broader look at the interfaces between all the constituent elements and players in the territory, in order to characterize the determinants of sustainable local development. Moreover, this approach is

usually associated with a perspective of 'entrepreneurial ecosystems' that focuses on the capacity and voluntarism of innovative actors/companies, relegating the other elements the institutional framework and the social, cultural, territorial, political and environmental context - to a facilitating background role. As La Rovère et al. (2020) warn, relegating systemic factors to an oversimplified "background" role implicitly or explicitly suggests that there might be some sort of ideal set-up of environmental conditions. Therefore, decontextualized benchmark perspectives can be applied that aim at deobstaculating and liberating the innovative spirit of the Schumpeterian entrepreneur.

In the scope of this literature, the impact on local development is mostly circumscribed to the economic dimension in a short or medium term horizon (Mian 1997, Kim and Jung 2010, Sentana et al. 2016, Al-Mubarak and Schrödl 2011, Oliveira et al. 2017). Thus, the dimensions considered and the metrics employed revolve around the number of companies supported and graduated and their market success, such as employment and income. Secondarily, but still in the narrow domain of the economic perspective, some approaches also consider traditional innovation metrics, such as patents and innovation rate. We refer to a short to medium term horizon precisely because we consider that, in a long-term and systemic perspective, development cannot do without advances in several other areas of the social, institutional and environmental structure that condition and impose limitations on business.

Many studies focusing on incubators and technology parks begin to explore interfaces with the territory in a more systematic way (Carayannis et al. 2012, Carayannis and Rakhmatullin 2014, McAdam et al. 2016, Poonjan and Tanner 2018, Harper-Anderson and Lewis 2018). However, they do not effectively explore the dialectical relationship inherent in the territory as a social construct. Thus, the mechanisms through which incubators and technology parks may impact on local and regional development in a broad sense are not explored, but only the inverse causation, i.e., how characteristics of the territory may condition the performance of these organisations and their degree of success (associating success to the same aforementioned economic metrics).

Thus, seeking to advance towards an analytical framework adherent to the objective of this study, we refer to conceptual discussions and empirical experiences related to the concept of "Developmental University" and its conceptual expansion to "ICTs for development". This concept deals with the mobilization of innovation systems for solving social, environmental and economic problems. The centrality of Scientific and Technological Institutions (STIs) for development depends on the relations and interaction established by them and their ability to mobilize skills and direct efforts towards a certain objective.

This framework suggests to direct the focus of universities (in a broad perspective, the ICTs) to the problems and particularities of the territory where they are inserted, stimulating both the actors to demand knowledge to solve their problems and the innovation process oriented towards such ends.

This process ranges from the adaptation of existing solutions to local particularities to novel solutions, emphasizing local empowerment, which takes into account environmental and social aspects (Arocena and Sutz 2005, 2014; Velho 2007). Through partnerships, dialogue and local governance, it is possible to stimulate the ICTs to generate knowledge and innovations that are adherent to the challenges and needs of society and the productive structures existing in the territory. Thus, it is possible to promote local and regional development by fostering the demand for knowledge that takes into account social, environmental, territorial and institutional issues, stimulating the consolidation of systemic connections and interactions (Arocena et al. 2018; Cassiolato and Lastres 2018).

The scenario in the 1990's and early 2000's in Brazil was marked by a decrease in State participation, with expectations that the private sector would fill the gap of demand for socially relevant knowledge, which unfortunately did not materialize. The proliferation process of technological parks and incubators is directly associated with this logic of greater private participation. From this perspective, incubators, technology parks and similar initiatives would be more aligned with the perspectives of the global "North" of stimulating the cooperation of universities with the productive structure, especially in niches of greater technological dynamism. These models of the "entrepreneurial university" or of the university as a producer of knowledge for companies proves to be disconnected from the reality of society and of almost all Latin American universities (Arocena et al. 2014; Cassiolato et al. 2018; Brundenius et al. 2009).

Of course there are few cases of virtuous and dynamic niches of technology development and application. But these success cases rely on far more complex long term historical processes of institutional construction. In opposition, considering the reality of almost all local territories in a country like Brazil and the recent proliferation of incubators and technology parks another perspective is needed if they want to fulfil their purpose as instruments for promoting territorial development.

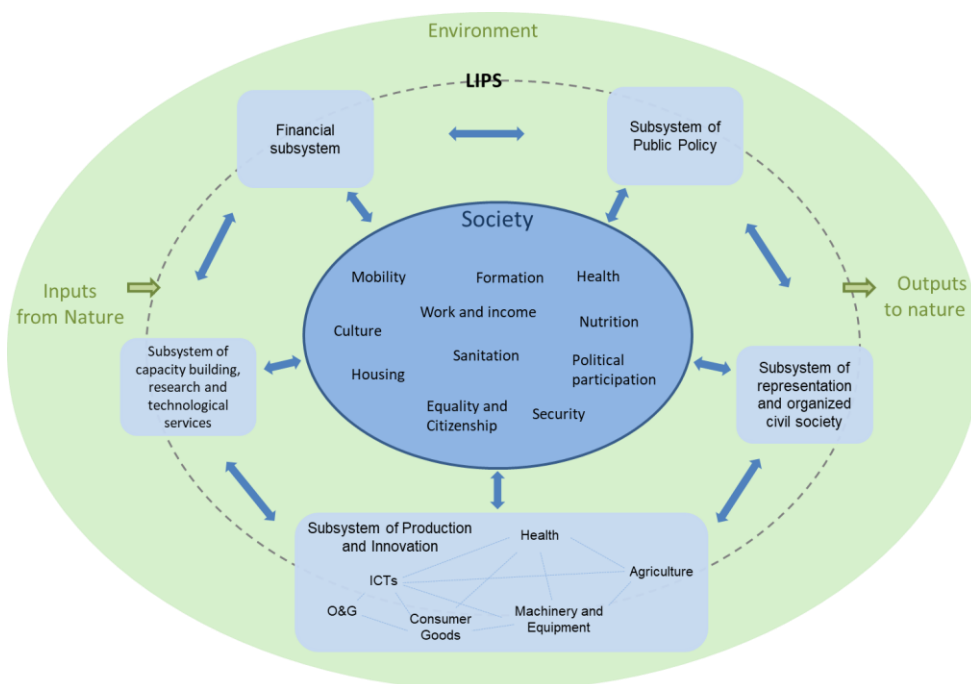
Thus, the potential solution points to the promotion of the interaction of ICTs with the productive and social fabric, the strengthening of interactive learning spaces (Arocena and Sutz, 2002), the incorporation of sustainability challenges in the demand for knowledge of these organizations and the direction of innovative efforts towards the development and introduction of solutions for such challenges (Arocena et al., 2014).

1.4. Implications for the Analytical Framework

The discussions above call for an adaptation of the Innovation System framework, helping to identify how and to what extent ICTs, and especially incubators, accelerators and technology parks, can contribute to local sustainable development. We start with the schematic illustration of a Local Innovation and Production System (LIPS) in Figure 1, which summarizes the main structural and relational elements in the territory.

First, the illustration highlights the natural environment as the macrostructure in which all social processes take place, taking into account the different types of inputs coming from nature and the outputs to nature generated by production and consumption activities. Second, unlike the usual representations of innovation systems, the society subsystem is at the centre. It constitutes the locus of monetary demand but it also encompasses broader and diverse phenomena, related to the use of goods and services (through non-market relations and the use of public goods and services) related to life in a broad sense. Here we recover Sen's (1999) central argument, which qualifies development as the capacity of people to develop their potentials and live the life they desire. Based on the discussion of multidimensional sustainability, impacts related to such dimensions are exemplified. Ultimately, it comes to subordinating production and innovation to the challenges of society for its development.

Figure 1 – Local Innovation and Production System in the context of sustainable development



E Source: Own elaboration

In the circle around the Society subsystem, we find the subsystems related to types of actors and their functions in the LIPS. The production and innovation subsystem is exemplified by several industries. The capacity building, research and technological services subsystem encompasses, among others, incubators and technology parks. Moreover, the scheme presents the financial subsystem, the public policies and promotion subsystem, the representation and organized civil society subsystem, which encompasses different types of stakeholders' that need to be articulated, as discussed in the political and institutional dimension of sustainability.

Finally, the blue arrows indicate the flows of goods and services, knowledge and other intangible and symbolic elements. Identifying what these flows are and how to analyse them is the main challenge of this research agenda. While some, such as goods and services and some types of knowledge flows, are well address by the IS literature, other constitute open research agendas.

The objective of the present work is to contribute to a reflection on how IATPs' influence may be requalified, guided by precepts of territorial sustainability. Therefore, the characteristics and strategies of these institutions are at the centre of discussion. Based on Sachs' (2009) multidimensional perspective of sustainability, we identify five main dimensions of sustainability, which will guide our analysis. They can be characterized as follows:

- Ecological/Environmental Dimension: preservation and conservation of nature; enable ecosystems to return to equilibrium after being affected by human action;
- Territorial Dimension (urban/rural): balance in rural and urban configurations; improvement in the urban environment, taking into account the challenges of life quality in cities;
- Social/Cultural Dimension: social homogeneity, income distribution, employment, access to resources, services and favourable conditions for personal development, respect for tradition and innovation, cultural diversity and self-confidence;
- Political Dimension: human rights, partnerships to implement the national project, social cohesion, citizenship, voice and participation of society in public policies;
- Economic Dimension: balanced intersectoral development, food security, modernization of production instruments, autonomy in scientific and technological research and innovation.

Based on this analytical framework, this research sought to identify and qualify the initiatives mobilized by the IATPs and the companies they support in order to identify to what extent they contribute to sustainable local development.

2. Methodology for Assessing the Contribution of IATPs to Sustainable Development

Aligned with the methodological proposal of Fischer et al. (2020), questionnaires were elaborated which requested information only about structures, processes and initiatives, whose veracity may be proved through documents². This option is of central importance for the questionnaire to constitute the basis for a perennial and structured monitoring system, run by the Ministry of Science, Technology and Innovation. It would be up to the IATPs' managers to fill in the information periodically. Keeping it up to date would be a prerequisite for participation in support calls/edicts. Proof of the information provided would be required if the organization is actually selected for support.

Even if we seek to shed light on issues not well covered by traditional literature, we choose to contemplate also the parameters traditionally considered by the literature on innovation environments and innovation ecosystems. Thus, it mixes questions covering traditional issues with novel questions we propose for gathering information related to a systemic perspective of contribution to local sustainable development.

All the questionnaires have a common core and present adaptations according to the specificities of each of the organization types we cover (incubators, accelerators or technology parks). The questionnaires are organised into five blocks:

- Block 1 - Articulation and alignment with the external context - the questions in this block aim to characterize the degree of convergence of the IATPs with the characteristics of the territory, from the point of view of valuing the solution of the territory's development challenges, of aligning with the most important productive systems and of converging with the local development strategies and policies;
- Block 2 - Interaction networks with the Local Innovation and Production System - the questions in this block investigate the network relations established with various types of actors in the local system, contemplating, besides the traditional ones, also organizations related to training, technological diffusion and basic industrial technology, as well as civil society organizations and other social actors. Thus, the focus is broadened beyond the "innovation ecosystems" considering the broad set of actors potentially involved in processes of generation, use and application of knowledge;
- Block 3 - Interaction networks and internal environment - the questions in this block are aligned to what traditional literature emphasizes as essential in terms of provision of collaborative infrastructure, incubation activities and promotion of networking events;

- Block 4 - Management, Governance and Business Support Services - the questions in this block explore the management and governance profile of IATPs, but emphasize aspects such as: (i) consideration of impacts on all dimensions of sustainability in feasibility studies and planning; (ii) natural and environmental resource management mechanisms; (iii) incentive and support structures for the development of solutions oriented to the territory's challenges in all dimensions of sustainability;
- Block 5 - Results - the questions in this block contemplate the traditional result variables, but highlight the effective introduction of solutions (innovations in the broad sense) with potential impact on local development in all dimensions of sustainability.

An online form was used for gathering responses from July 12th to August 6th 2021. We opted to cover the whole population of IATPs mapped in various surveys³. Table 1 summarizes the number of IATPs invited and the number of responses obtained. The last column shows for which level of sampling error the sample may be considered statistically significant⁴.

Table 1- Number of incubators, accelerators and technological parks invited, number of respondents, response rate and sampling error

Organizations	Invited	Respondents	Response rate	Sampling Error
Incubators	288	91	34,7%	Eo=8,7%
Accelerators	45	14	35,9%	Eo=22%
Technology Parks	101	37	39,4%	Eo=13%

Source: Own elaboration

The next methodological step was the construction of a system of indicators and synthesis index, as a basis for a system of evaluation and monitoring of IATPs, offering development organizations a practical tool with objective criteria for prioritization according to their contribution (potential and effective) to sustainable regional development.

Some procedures were adopted to translate the answers to each question into an indicator, for the subsequent aggregation of indicators by broad analytical categories and calculation of a synthesis indicator. For some questions, the calculation of the indicator is made by combining the answers with indicators built on secondary data collected from official sources. These indicators relativize the answers to the questionnaire based on the territory's characteristics, thus verifying to what extent the IATPs converge with the territory's potentialities and needs. Their construction contributes to relativizing high scores which would tend to result from the mere location of the IATP in highly developed and dynamic territories⁵.

From calculating summary indicators, we used a weighted average of the individual indicators of each block. The attribution of weights is necessarily subjective according to the dimensions considered to be more relevant. What is more relevant is informed by the conceptual bias adopted. The choice of weights inspired by traditional literature of innovation environments and innovation ecosystems tends to attribute great relevance to enshrined measures of innovation input and output. On the other hand, the bias explicitly pursued in the present study is guided by the contribution to local and regional development from the perspective of multidimensional sustainability. Thus, greater weight is attributed to the indicators that best reflect the convergence with the needs and characteristics of the territory, the articulation with the local context and the initiatives

3. Main Results

3.1. Adherence with the Territory

The questions in the first block explore the adherence of IATPs to the characteristics of the territory where they are located. It is based on the understanding that these organizations should be as more relevant and deserving of public support the more they are linked to the territory, articulating with its productive, scientific, technological and innovative competences, as well as with its development strategies.

The first indicator contrasts the dimensions of sustainability, to which importance is attributed as a selection criterion for new firms to be supported, with the degree of development of these dimensions in each territory. To the extent that the organisation attributes importance to each of the dimensions of sustainability as a selection criterion, points are added. However, additional points are awarded the greater the gap between the importance assigned to the dimension and the value of the territory's development indicator in that dimension⁶. Thus, the greater the importance attributed to particularly fragile dimensions of sustainability in such a region, the higher the organization's score. It follows from this construction logic that IATPs located in highly developed territories, in relation to the dimensions of sustainability, tend to score less than IATPs with the same profile in less developed regions. In other words, the aim is to relativize the score to better reflect the organizations own qualities, controlling for possible benefits that derive from the insertion of IATPs in virtuous environments, and to give priority to less developed regions.

Table 2 - Adherence of selection criteria with sustainability dimensions – average scores

	Technology Parks	Incubators	Accelerators
Economic Dimension	0,678	0,672	0,677
Environmental Dimension	0,391	0,418	0,377
Social Dimension	0,248	0,486	0,370
Institutional Dimension	0,142	0,285	0,394
Territorial Dimension	0,391	0,418	0,474
Indicator 1.1 - Criteria for selection of companies and adherence to the Region's challenges	0,359	0,461	0,458

Source: Own elaboration

A very similar pattern is observed among the three types of organizations, with strong emphasis on the focus on the economic dimension. The criteria usually considered in the literature of innovation environments are the ones that scored highest: "Alignment of the firm with the priority sectors of the IATP", "Intensity of the R&D and innovation", "Culture of collaboration with Science and Technology Institutions (STI) and/or other companies". When considering the criteria that are associated with direct impacts on the territory, once again those that are consolidated in the traditional discourses stand out: "Capacity to generate employment, revenue and productive linkages in the region". On the other hand, there is a gradual construction of a greater sensitivity related to socio- environmental impacts, highlighting impacts related to the environmental/ecological dimension: "Development of solutions oriented to the conservation of the environment and the reduction of environmental impacts of production activities". And one third of the IATPs already have a good perception about a broader orientation towards regional and local development, contemplating aspects of the social (health, education and culture) and territorial/urban dimensions.

The second indicator of Block 1 has special importance insofar as it reflects the degree of adherence of the scope of action of IATPs with the existing productive structures in the region.

To measure the relative importance of the production systems in the territory, a modified locational quotient was calculated to identify the territory's predominant sectors. This quotient was used as a weighting factor. The more a sector is relevant for the regional economy, the more the organization scores if

this sector constitutes one of its foci⁷. It follows from the construction logic that it is relatively more difficult for IATPs located in a highly developed region to obtain a high score, given that these regions tend to present a greater diversity of relevant productive structures. Also, especially low scores will be obtained in those cases where the organization focuses only on sectors that are not present in the region.

As expected, productive activities associated with IT figure as the focus of the vast majority, together with other systems such as electronics and telecommunications. The focus on productive systems and areas of knowledge broadly associated with health is also noteworthy. Biotechnology, the productive system of health care and assistance, pharmanchemistry and pharmaceuticals, cosmetics and hygiene, and medical and dental equipment are mostly mentioned by technology parks. On the other hand, mainly incubators and accelerators focus on sectors with great niche opportunities for smaller innovative companies, such as network industries and public services, commerce (wholesale and retail), financial sector, tourism and entertainment, specialized business services and education. The focus on the primary sector is also noteworthy, given the outstanding vocation of several fractions of the national territory.

Although it may be desirable to have organisations that promote the emergence of new sectors of activity, especially those of higher technological intensity, empirical experience shows that, usually, the disconnection with the bases of productive and technological competences present in the territory's economy leads IATPs to have only an anecdotal importance with no impact on the territory's economic development (Matos et al. 2021). On the other hand, the focus on high technology niches has greater coherence in those territories where S&T competences already exist in these areas.

In fact, the highest scores for all three types of organizations was above 0.8. These cases relate mostly to regions with cities of intermediate size and a with low or medium level of productive diversification. Both the convergence with high tech sectors and with traditional sectors and agroindustry contribute for high scores. However, the averages are significantly lower due to two cases: (i) IATPs with a deliberate focus on high-tech niches without any adherence to the scientific, technological and productive competences of the territory; (ii) innovation environments inserted in territories with more diversified and dynamic productive structures, but with a focus on very specific sectors.

Finally, the third indicator of this block refers to initiatives that denote convergence with the region's development plans and public policies. It is noteworthy that the three types of organizations most frequently indicate formal participation in local policy forums and councils. A relevant percentage also applies to the participation of representatives in governance instances of LIPs. Together, these are key spaces for interaction and daily mediation of

interests and alignment of efforts and initiatives, which are essential for IATPs to act effectively in favour of local development. Notably, local policy forums and councils can encompass several areas besides the economic one, such as, for example, health, culture, sanitation, education, etc.

Based on the attribution of the weights indicated in the last column, a summary indicator of the block was obtained. The average value is relatively low, given that the same organisations did not obtain high scores for all individual indicators. Furthermore, it is a methodological choice to relativize the scoring potential of IATPs that are in highly developed and virtuous regions.

Table 3- Indicators of the first block of the technology parks questionnaire

	Technology parks			Incubators			Accelerators			Weight
	min	average	max	min	average	max	min	average	max	
Question 1.1 - Criteria for selecting companies and adherence to challenges in the Region	0.000	0.359	0.634	0.039	0.461	0.735	0.205	0.458	0.710	2
Question 1.2 - Adherence to the production structure	0.000	0.259	0.864	0.000	0.275	0.900	0.100	0.458	0.923	2
Question 1.3 - Alignment with Policies	0.000	0.747	1,000	0.000	0.481	1,000	0.000	0.509	0.900	1
Block 1	0.067	0.397	0.652	0.089	0.390	0.773	0.317	0.468	0.597	-

3.2. Interaction Networks with the Local Innovation and Production System

This block explores the potential articulations that take place with the external environment. The scope of potential articulations and types of activities is informed by the IS and LIPS literature. Information was obtained on the existence of formal agreements or covenants of the IATPs with different external actors, involving various relevant activities from the point of view of the dynamics of learning, competence building and innovation. In the case of civil society organisations and cooperatives, informal but perennial links were also considered.

For the three types of organisations, the indicators show strong interaction with universities and ICTs, given the large proportion of IATPs that are hosted by these institutions. The activities objectively directed towards the development and introduction of innovations stand out: scientific research activities, sharing

of laboratory infrastructure, consultancy, training and technological dissemination, technological development and technology transfer agreements. But, almost the same importance was attributed to the construction of mechanisms and channels to identify challenges and needs of local society and to stimulate resident companies to develop solutions. As evidenced by the literature on Developmental Universities and on social entrepreneurship, these mechanisms are of fundamental importance to reduce the mutual lack of knowledge between ICTs and society and to build effective bridges for interaction.

Even if not directly related to innovation activities at the technological frontier, professional training, technical assistance and maintenance centres constitute a fundamental interface with respect to the broad regional productive fabric. The articulation with these actors can benefit resident companies, as they constitute interaction channels with many companies and trained professionals. They constitute important channels for the diffusion of productive and innovative skills in the region.

The interactions with civil society organisations and cooperatives are usually not considered in studies on innovation networks. But there are very important experiences of incubators and other STI that have as their sole or complementary focus the support to popular cooperatives and productive inclusion, aligned with the precepts of solidarity economy. These experiences reveal the broad potential that exists for the articulation of the structured science, technology and innovation base of the territory with the challenges of social development and sustainability (Apolinário and Silva, 2020; Marcelino et al., 2020).

A good surprise was that the survey revealed relatively high average values for the indicator associated with the interaction with civil society organizations, social enterprises and cooperatives (0.619 for parks, 0.513 for incubators and 0.82 for accelerators). This shows that there is far more scope for interaction and capacity building than the traditional literature on innovation ecosystems and IATPs suggests. These are important channels for challenges and needs to be identified and for the potential beneficiaries to engage actively in their development and application, as preconized by the concept of inclusive innovation (Soares et al. 2013; Soares and Cassiolato 2013; Chataway et al. 2014; Bortagaray and Gras 2014). For this reason, and due to the choice of valuing interactive processes that go beyond the traditional/usual ones, we assigned the weight 2 to this indicator, while interaction with the other types of actors received weight 1.

Table 1- Indicators of the second block of the questionnaire

	Technology Parks			Incubators			Accelerators			Weight
	min	average	max	min	average	max	min	average	max	
Question 2.1 - Interaction with universities	0.000	0.874	1,000	0.000	0.769	1,000	0.000	0.800	1,000	1
Question 2.2 - Interaction with other ICTs	0.000	0.600	1,000	0.000	0.455	1,000	0.300	0.790	1,000	1
Question 2.3 - Interactions with professional training, technical assistance and maintenance centres	0.000	0.452	1,000	0.000	0.332	1,000	0.000	0.560	1,000	1
Question 2.4 - Interaction with Civil Society Organizations, Social Enterprises and Cooperatives	0.000	0.619	1,000	0.000	0.513	1,000	0.000	0.820	1,000	2
Question 2.5 - Interaction with Firms“outside” the organization	0.000	0.552	1,000	0.000	0.433	1,000	0.000	0.350	0.900	1
Block 2	0.067	0.619	1,000	0.000	0.503	1,000	0.233	0.690	0.983	-

Source: Own elaboration

3.3. Internal Interactive Networks

This block explores the characteristics and initiatives directed towards the internal environment of the IATPs. These are mostly aspects consecrated in the traditional literature on innovation environments, which indicates the constitution of a fruitful and stimulating internal environment as the main mission of these organisations.

The organization of networking events and the mobilization of business incubation activities constitute a focus of activity for these organizations, in such a way that relatively high averages were obtained for the indicators of question 2 and 3. The improvement of information and communication

technologies (ICTs) opens several opportunities for virtual or distance interaction. Thus, the virtual incubation modality carries great potential to provide greater capillarity to innovation environments, reaching companies in other regions of the state.

The incubation of social enterprises is undertaken by one third of the parks, 47% of the incubators and 55% of the accelerators. These data denote a significant advance in the perception of organizations as to the importance of greater articulation with their territories, overcoming the posture of disconnected islands of excellence. More than that, it is interesting to note these activities being promoted by organisations that also operate at the more technological and market-oriented end. The evidence helps to overcome the dichotomous perspective that suggests that these organizations should either focus on the technological and entrepreneurial dimension or on the social dimension.

Other aspects explored in this block are aligned with the traditional literature on innovation environments, investigating aspects such as the supply of infrastructure to favours internal interactive activities. We chose not to explore them here, since the objective is only to highlight issues that are more directly aligned with the focus on sustainable local development.

Table 2- Indicators of the third block of the questionnaire

	Technology Parks			Incubators			Accelerators			Weight
	Min	average	Max	Min	average	Max	Min	average	Max	
Question 3.1 - Anchor Companies	0.000	0.410	1,000	-	-	-	-	-	-	1
Question 3.2 - Networking events	0.000	0.771	1,000	0.100	0.623	1,000	0.200	0.780	1,000	2
Question 3.3 - Business Incubators / Virtual or Remote Incubation	0.000	0.844	1,000	0.000	0.674	1,000	0.300	0.880	1,000	2
Question 3.4 - Social Enterprise Incubators	0.000	0.371	1,000	0.000	0.440	1,000	0.000	0.600	1,000	2
Question 3.5 - Basic	0.100	0.719	0.900	0.000	0.664	0.900	0.000	0.170	0.400	1

collaborative infrastructure										
Question 3.6 - Advanced collaborative infrastructure	0.000	0.609	1,000	-	-	-	-	-	-	1
Block 3	0.011	0.622	0.989	0.033	0.584	0.989	0.256	0.686	0.900	-

3.4. Management, Governance and Business Support Services

This block explores the management and governance of the IATPs. As in the previous block, many aspects are aligned with the traditional literature on innovation environments and the proposed indicators for their assessment. Due to space limitations, issues that discuss the existence and characteristics of strategic planning, management certification, business development support, internationalization program and company monitoring process will not be discussed here. But the questions that make up each indicators can be checked in Appendix 1.

Table 3 - Indicators of the fourth block of the questionnaire

	Technology Parks			Incubators			Accelerators			Weight
	Min	average	Max	Min	average	Max	Min	average	Max	
Question 4.1 - Participants in the Governing Body	0.200	0.743	1,000	0.000	0.4	1,000	0.000	0.322	0.700	2
Question 4.2 - Strategic Planning	0.000	0.679	1,000	0.000	0.687	1,000	0.100	0.900	1,000	1
Question 4.3 - Feasibility Study	0.000	0.448	1,000	0.000	0.251	1,000	0.000	0.444	1,000	2
Question 4.4 - Certifications in Management	0.000	0.283	1,000	0.000	0.38	1,000	0.000	0.400	0.600	1
Question 4.5.1 - Management of Natural and Environmental Resources (park)	0.000	0.543	1,000	0.000	0.284	1,000	0.000	0.422	1,000	3
Question 4.5.2 - Management of Natural and Environmental Resources (support for	0.000	0.479	1,000	0.000	0.393	1,000	0.000	0.422	1,000	3

companies)										
Question 4.6 - Incentives to solve challenges in the territory	0.000	0.250	1,000	0.000	0.286	1,000	0.000	0.528	1,000	6
Question 4.7 - Business development support	0.000	0.696	1,000	0.000	0.71	1,000	0.500	0.883	1,000	1
Question 4.8 - Internationalization program	0.000	0.388	1,000	0.000	0.435	1,000	0.000	0.722	1,000	1
Question 4.9 - Process for monitoring resident companies	0.000	0.600	1,000							1
Question 4.10 - Frequency of monitoring of resident companies	0.000	0.717	1,000							1
Block 4	0.218	0.456	0.971	0.067	0.378	0.952	0.229	0.525	0.800	-

Source: Own elaboration

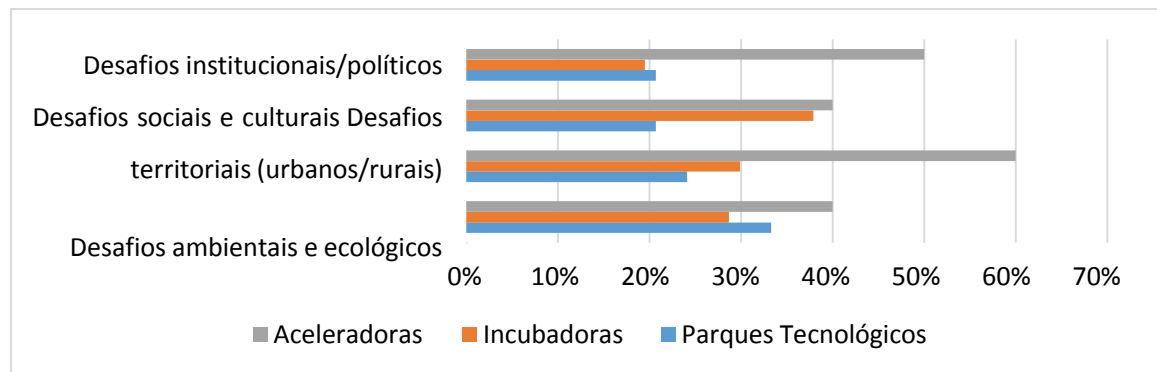
On the other hand, we assigned differentiated weight to indicators that align with our focus. The first indicator scores better the more diversified is the composition of the governing body, including representatives from government, STIs and civil society. The third indicator takes into account not only traditional economic variables of feasibility studies, but also the consideration of feasibility in relation to environmental and social aspects.

Question 4.5.1 analyses the organizations' initiatives in the management of natural and environmental resources and question 4.5.2 analyses the support offered by parks to companies to adopt such measures. As expected, a significant portion of technology parks adopt such practices. On the other hand, such initiatives are less frequent in the case of incubators and accelerators, given the development stage and the size of the companies supported, which may contribute to prioritize short- term consolidation and growth objectives.

Finally, it was decided to assign a differentiated weight to question 4.6, which investigates the existence of explicit incentives for resident/supported companies to seek solutions to territorial challenges in the environmental and

ecological, social and cultural, territorial and institutional/political dimensions. Figure 2 presents the percentages of IATPs that mobilize such initiatives.

Figure 2 - Incentives offered by IATPs for supported companies to engage in the search for developing solutions to the challenges of the territory associated with dimensions of sustainability



Source: Own elaboration

The environmental and ecological dimension is contemplated by 33% of the parks, about 29% of the incubators and 40% of the accelerators. This dimension already has greater consolidation in business and public policy discourses and several market niches are already established for solutions developed in this area. Here we find initiatives related to more efficient agricultural practices and with less environmental impact, as well as several technologies related to energy efficiency, new materials, etc. One park reported that it offers incentives to non-resident companies in the area of sustainability consulting with the construction of technological roadmaps. One incubator reported that it encourages companies to work with agro-ecology and forest recuperation, extractivism, integration of crop/livestock farming with forests and organic certification. Another one reported that it works in the areas of agro-ecology, rural sanitation, forest recuperation and restoration. Different incubators also reported actions, incentives, evaluations or training related to the treatment and disposal of corporate waste and other environmental impacts, including challenges to solve problems in the area. Finally, one incubator declared that it evaluates environmental and social impacts caused by incubated companies' activities, helping them to mitigate those impacts. One accelerator promotes hackathons focused on environmental and ecological dimensions. Another one launched a sustainable innovation program focused on an agricultural production chain.

Also, a significant percentage of parks (24%), incubators (30%) and accelerators (60%) mobilize explicit stimuli for companies to introduce solutions related to the challenges of the territorial dimension. Many flourishing areas for technological development and market opportunities, such as technologies and solutions related to the concept of smart cities, fall within this scope. Some

technology parks organize hackathons, university and business challenges involving students, universities, local entrepreneurs and municipalities aiming to find solutions to territorial challenges. One park reported the development of a smart cities pilot project for a region.

About 21% of parks, 38% of incubators and 40% of accelerators mobilise formal stimuli for companies to develop solutions related to the social and cultural dimension. These kind of solutions frequently do not meet well-structured market opportunities, even if they may benefit large fractions of local society. Eventually, these are areas where demand-side stimuli are not yet well structured. Examples in the areas of popular housing and health, however, show how governmental initiatives such as technological orders and the use of purchasing power can provide the springboard for these products and services to mature and consolidate market spaces.

One interesting example involves universities, companies, civil society organisations and public authorities in an initiative that aims to connect social demands with entrepreneurs of the technology park. Other initiatives cited by technology parks are the competition for the transformation of research projects into socio-environmental solutions for the community, the refurbishment of computers for digital inclusion with entrepreneurial training for young people. Many incubators declare to support social and cultural events and to offer qualification and professional training courses mediate internship opportunities at local companies. One incubator promotes a project to foster employment and income through handicrafts in connection with the local cultural identity.

Finally, about 21% of technology parks, 20% of incubators and 50% of accelerators offer explicit incentives for the companies they support to mobilize innovative efforts aimed at the institutional/political dimension. They encompass initiatives that impact on the transparency of public management, on the possibility of political participation of citizens, on the securing of civil rights of marginalized fractions of local society. An outstanding example comes from an incubator in the northeast of the country. It supports a collaborative innovation laboratory focused on Public Management solutions.

The percentages of IATPs that mobilize explicit initiatives to stimulate firms to develop solutions related to the dimensions of sustainability are very significant. On average, a quarter of the technology parks and about a third of the incubators and accelerators already direct explicit stimuli with ample potential impact on local sustainable development. Policy organizations can contribute for the greater diffusion of this mid-set with the registration and diffusion of such virtuous experiences and, of course, with the consideration of these types of initiatives as formal selection criteria in edicts and public calls for support.

3.5. Direct Outcomes

The fifth block investigates the direct outcomes of the initiatives, both those traditionally covered in the literature (questions 5.2 to 5.5 and 5.7 to 5.9 in table 7) and those related to the challenges of sustainability. Not coincidentally, the traditional indicators present significantly high average scores, considering that they are the traditional focus of evaluation of these organizations. According to the methodological proposal of this study, we decided to assign less weight to these questions (weight 1) since they are directly aligned with the already consolidated perspectives involving the management of innovation environments and refer to traditional variables of innovation input and output.

Table 4- Indicators of the fifth block of the questionnaire

	Technology Parks			Incubators			Accelerators			Weight
	min	average	max	min	average	max	min	average	max	
Question 5.1 - Introduction of solutions with an impact on sustainability	0.000	0.472	1,000	0.000	0.410	1,000	0.208	0.520	1,000	6
Question 5.2 - Financial Sustainability	0.000	0.526	1,000	0.000	0.395	1,000	0.300	0.729	1,000	1
Question 5.4 - Occupancy rate	0.000	0.550	1,000	0.000	0.532	1,000	-	-	-	1
Question 5.5 - Jobs in Research, Development and Innovation	0.000	0.681	1,000	0.000	0.494	1,000	0.010	0.583	0.890	1
Question 5.6 - Qualification of human resources	0.000	0.454	0.875	0.000	0.298	1,000	0.000	0.472	0.949	2
Question 5.7 - Intensity in Research, Development and Innovation	0.000	0.485	1,000	-	-	-	-	-	-	1
Question 5.8 - Intellectual property	0.000	0.538	1,000	0.000	0.297	1,000	0.000	0.383	0.900	1
Question 5.9 -	0.000	0.371	1,000	0.000	0.251	1,000	-	-	-	1

New Graduated Companies										
Question 5.10 - Social Enterprises Supported	0.000	0.154	1,000	0.000	0.236	1,000	0.000	0.286	1,000	2
Block 5	0.000	0.422	0.824	0.000	0.366	0.812	0.331	0.466	0.682	-

Source: Own elaboration

On the other hand, we decided to assign greater weight to indicator 5.10, which refers to the number of supported social enterprises. Question 5.6 is usually associated with the group of traditional indicators in innovation literature. However, a different methodology was chosen for the construction of the indicator, so that it relativizes the information in light of the characteristics of the local territory. The traditional indicator tends to reward parks located in more dynamic and developed areas, usually marked by the presence of several higher education institutions, which makes it relatively easier to attract professionals with master's and doctoral degrees. The indicator expresses the relative difference between the percentage of masters and doctors linked to companies in the park and the ratio of masters and doctors graduated in that region per 100 inhabitants per year. Thus, the organizations that manages to attract and attach to their companies a percentage of masters and doctors that is significantly higher than the masters and doctors graduates in the territory scores best.

Finally, we highlight the first question of this block. It addresses the most direct and central dimension of results, the effective introduction of innovations. We opted to ask for the "introduction of solutions", since the term "innovation" may be mistakenly associated exclusively with technological innovations and those close to the technological frontier. Solutions, as a broader term, would be able to encompass innovations aimed at solving the challenges of the territory, including what is characterised as social technologies, frugal or under-the-radar innovations (Kaplinsky 2010; Cozzens and Sutz 2012; Johnson and Andersen 2012).

As can be depicted in appendix 1, we asked for "solutions" with several different impacts. A total of 24 options were presented seeking to encompass a broad set of potential impacts. Afterwards, these potential impacts were grouped according to the predominant dimension of sustainability they relate to.

As expected, innovations with impact on the economic dimension scored highest. The highest frequency was assigned to innovations that impact on efficiency and productivity, with the use of modern and appropriate technologies and processes. The second highest frequency refers to solutions that contribute to the expansion of formal jobs and income.

The dimension with the second highest frequency is the environmental and ecological. Several types of innovation present similar frequency: the conservation of natural resources; the use of renewable energy; technologies related to water supply, sanitation, waste collection and disposal; environmentally sound industrial processes and the reduction of waste generation with the implementation of one of the 5 R's (Reduce, Rethink, Refuse, Recycle, Reuse). On the other hand, innovations connected to the prevention and mitigation of natural disasters showed less relevant.

In the territorial dimension there is only one type of innovation with a relatively higher frequency of innovative companies. As previously highlighted, these are technologies and solutions related to the improvement of cities and their surroundings, encompassing aspects such as urban mobility, reduction of population density, technologies associated with the concept of "smart cities", etc. A relevant percentage of firms also introduced innovations that contribute to the access to safe and healthy food.

Innovations related to the social and cultural dimension present low frequencies. The positive exceptions refer to solutions focused on teaching/learning assistance for primary school students, digital inclusion of the population and access to health services, materials and equipment. As mentioned before, these are areas in which the public sector can play (and has occasionally played) a preponderant leading role, guiding innovative efforts and helping initiatives to achieve minimum scales via demand side support.

Innovations associated with the institutional and political dimension of sustainability presented the lowest average frequency. The positive exception relates to firms in accelerators and technology parks that introduced innovations that support participatory public management. Furthermore, the solutions focused on transparency in the disclosure of data from public institutions and in reducing tax evasion and combating other illegal practices also present a relevant frequency of innovators.

3.6. Summary Indicators

The table below presents the summary indicators of the five blocks and the synthesis index. According to the last line of the table, the average synthesis index scores 0.504 for technology parks, 0.421 for incubators and 0.567 for accelerators. However, in all three cases, we observe a significant amplitude of variation between minimum and maximum scores, which denotes the great diversity that exists amongst the organizations covered by the research and the ample potential for them to advance in positioning, practices, incentive structures and initiatives oriented towards sustainable local development.

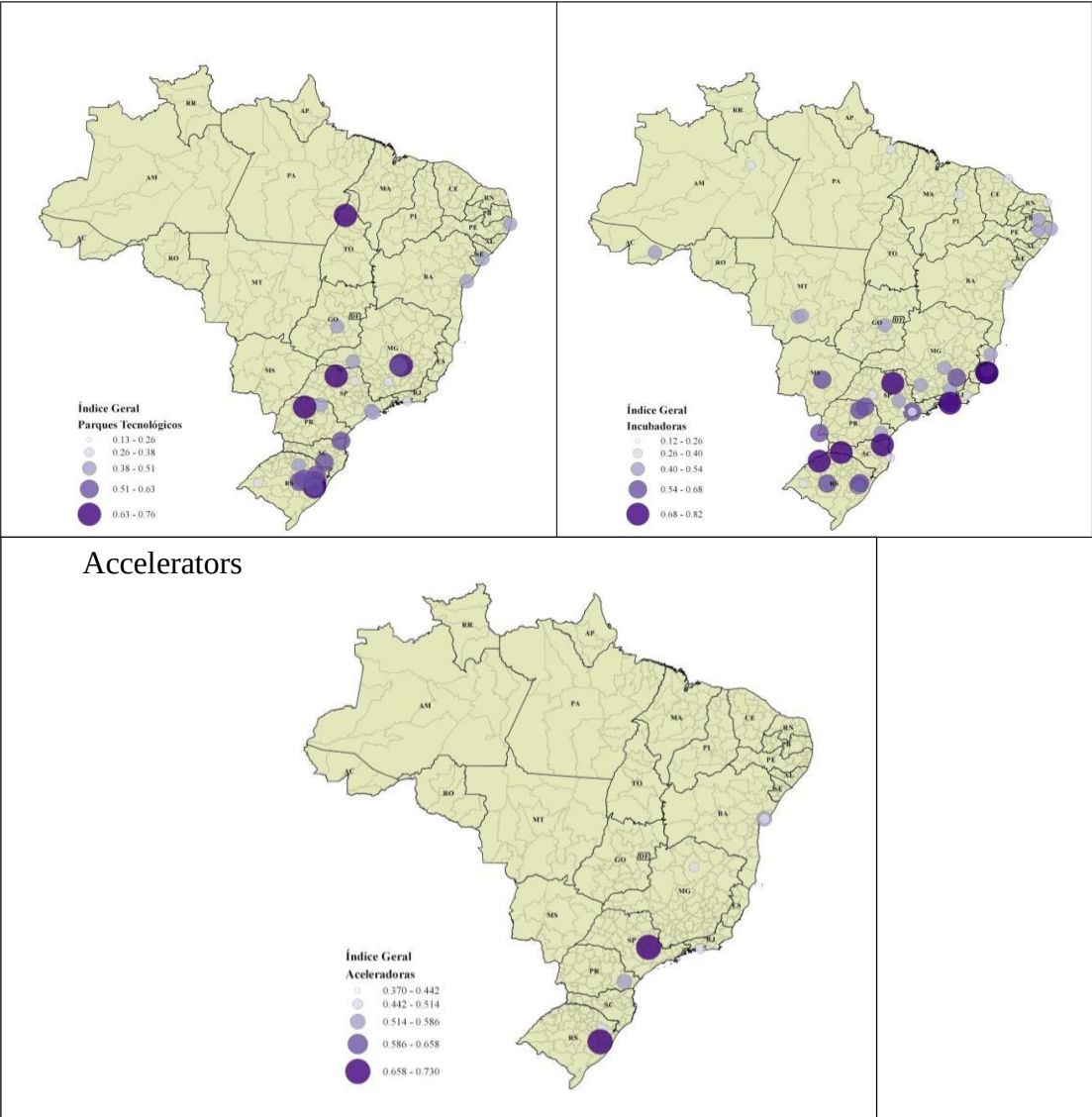
Table 5- Indicators of the blocks and summary index

	Technology Parks			Incubators			Accelerators			Weight
	min	average	max	min	average	max	min	average	max	
Block 1 - Articulation and alignment with the context outside the Organization	0.067	0.397	0.652	0.089	0.393	0.773	0.317	0.468	0.597	2
Block 2 - Networks of interactions with the Local Innovation System	0.067	0.619	1,000	0.000	0.504	1,000	0.233	0.690	0.983	2
Block 3 - Interaction networks and internal environment of the Organization	0.011	0.622	0.989	0.033	0.588	0.989	0.256	0.686	0.900	1
Block 4 - Management, Governance and Business Support Services	0.218	0.456	0.971	0.067	0.378	0.952	0.229	0.525	0.800	2
Block 5 - Results	0.000	0.420	0.824	0.000	0.368	0.812	0.331	0.466	0.682	2
General index	0.133	0.504	0.761	0.119	0.421	0.811	0.451	0.567	0.731	-

Source: Own elaboration

The diversity of results can also be visualized in Figure 3. It is interesting to highlight the high score of technology parks located outside the main metropolitan regions, such as in the state of Tocantins, the inland of the states of São Paulo, Paraná and Santa Catarina. At the same time, several parks in metropolitan regions scored high, especially those located in the metropolitan regions of Belo Horizonte and Porto Alegre. On the other hand, parks located in the metropolitan regions of the capital cities of São Paulo and Rio de Janeiro and in the Northeastern states obtained only medium scores, denoting a significant open potential for a better articulation with their surroundings. As to incubators and accelerators, one also observes a concentration of incubators with highest scores in the South and Southeast regions of the country.

Figure 3 - Summary Index and Location of Incubators, Accelerators and Technology Parks



Source: Own elaboration

Final Remarks

This article summarises the effort to propose a methodological framework for the improvement of the National Programme of Support for Innovative Environments (PNI), in view of its contribution to sustainable regional and local development. To this end, a theoretical-analytical referential was built upon three pillars:

- Local Innovation and Production Systems (LIPSs) and the relationship with territorial development. This framework adopts a systemic perspective of the structures and dynamics of local development, establishing a bridge between productive activities and the territory in a broad sense. It emphasizes the interactive processes of learning, as a vector for the generation, dissemination and use of knowledge, cooperation and innovation in their broadest sense;
- The elements of multidimensional sustainability that provide the basis for the concept of local sustainable development, which calls for substantial changes in incentive structures in order to achieve the desired results;
- The perspective of developmental universities which calls for scientific and technological institutions to play a different role than the one preconized by the concept of entrepreneurial universities. Far more suited to the reality of less developed countries it puts especial emphasis on the interaction with local society, the identification of challenges and the mobilization of competences of the local innovation system to overcome them.

Thus, a new role is preconized for Incubators, Accelerators and Technology Parks as actors of the Local Innovation and Production Systems, which resources and capabilities should be directed towards the promotion of local sustainable development. Ultimately, it is about subordinating production and innovation to society's development.

The evaluation system we propose is meant to shed light on virtuous experiences and to help policy organizations to set an alternative incentive system. Questions seek to identify the alignment with characteristics of the territory, interaction and collaboration with different players of a broad perspective of innovation system, incentive structures explicitly oriented to the dimensions of sustainability and the direct results. Such questions were combined with questions addressing dimensions and variables tackled by traditional innovation ecosystem literature. Some of the main results deserve to be highlighted.

Technology parks: a great diversity was verified among these organizations, highlighting the ample potential for them to advance in terms of incentive structures and initiatives oriented towards sustainable local development. In general, parks showed better performances in questions related to interaction networks with the local innovation system (block 2 of the questionnaire) and to interaction networks and internal environment (block 3). We observed a good interaction with civil society organizations, social enterprises and even civil society actors and cooperatives. The indicators related to articulation and alignment with the external context (block 1), management, governance and support services (block 4) and park results (block 5) showed relatively low values, especially in the most relevant issues, which refer to sustainability challenges, adherence with the production structure and the introduction of

solutions with an impact on sustainability. We conclude that, overall, respondent parks show a low to medium alignment with the vectors – incentive systems, initiatives, projects and programs – that lead to sustainable local development.

Incubators: the synthetic indexes for incubators presented low to median values, revealing that there is plenty of room for advancement and greater alignment with the objectives of promoting sustainable local development. Incubators with highest scores concentrate in the South and Southeast regions of the country. From a general perspective, incubators perform similar to technological parks. The best results were for interaction networks with the local innovation system (block 2) and interaction networks and internal environment (block 3). The synthesis index presented low values for the block on the articulation and alignment with the territory (block 1), management, governance and support services (block 4) and results (block 5). Especially, low indexes related to initiatives directed towards the management of environmental and natural resources and the resolution of territorial challenges strike out. There is ample room for public policies to encourage greater engagement of incubators with territorial development, expanding their role and effective contribution to this process.

Accelerators: similarly, the synthetic indexes for accelerators presented low to median values. The highest indicators were found in blocks 2 and 3, suggesting that interaction networks are well aligned with the local innovation system and that there are good programs and initiatives that favour networks and interactive processes. Management, governance and support services (block 4), unlike parks and incubators, presented higher values, with emphasis on strategic planning, business development support and the follow-up process of accelerated companies. Incentives to solve the territory's challenges presented indicators with better values when compared to the other types of organization. The accelerators did not obtain high scores in the articulation and alignment with the external context (block 1). As for the results (block 5), the synthesis indicators were low, especially those referring to the introduction of solutions with impact on sustainability.

The results reinforce the importance of the adoption of a system for continuous monitoring and evaluation of IATPs that helps to set up an incentive system that induces these organizations to become important actors for constructing a fairer, more inclusive and sustainable society.

The debate about criteria for setting priorities for the allocation of scarce public support resources usually contemplates only two extremes. On the one hand, we have the perspective that resources should prioritise a few well-developed IATPs, in order to maximise their potential for generating high end innovations and new companies. On the other hand, the eagerness of universities and local government to create new innovation environments, considering them as a

golden ticket for the dynamisation of their territories. The present work proposes an intermediate path, which reconciles the importance of rationalising the use of scarce public support resources with the fundamental conception that IATPs are instruments for promoting regional development, which calls for favouring less developed territories.

Traditional approaches run the risk of confusing virtuosities of the innovation environment with virtuosities of the territory in which it is inserted, reinforcing a logic of "picking the winners". To the extent that more resources are directed to them, regional asymmetries are reinforced. In opposition, the option of this study was to contribute to an evaluation system that rewards the innovation environments more engaged in the interaction with the territory in a broad perspective. The scores for individual answers and the indicators for each question were conceived so as not to attribute differentiated scores to IATPs just because they are located in more virtuous regions with robust productive and Science, Technology and Innovation structures. On the contrary, they seek to reward the degree of articulation, adherence with the territory and contribution to its development, whether it is a highly developed territory or a territory marked by less robust scientific and technological institutions and less diversified and dynamic productive structures.

Of course, this is a novel attempt to build such an evaluation system. To what extent it fulfils the purpose for which it was designed depends on its use and continued refinement. Above all, the collection of data over time, providing a perspective of the evolution of the IATPs, will indicate which adjustments need to be made.

References

- ALLEN, D. N. (1988) Business Incubator Life Cycles. *Economic Development Quarterly*, vol. 2, no. 1, p. 19-29, Fev.
- AL-MUBARAKI, H.; SCHRÖDL, H. (2011) Measuring the effectiveness of business incubators: a four dimensions approach from a gulf cooperation council perspective. *Journal of Enterprising Culture*, Vol. 19, No. 4, p. 435-452, dez, 2011.
- AMARAL FILHO, J. (2001) Endogeneização no desenvolvimento econômico regional e local. *Planejamento e Políticas Públicas*. Brasília, n. 23, p. 261-286.
- APOLINÁRIO, V.; SILVA, M. L. (2020) Análise multidimensional da relação Universidade-Sociedade no Brasil: contribuições ao bem-estar a partir da Organização de Aprendizagens e Saberes em Iniciativas Solidárias. In: *Caminos hacia la transformación*, cap 6.
- AROCENA, R.; GÖRANSSON, B.; SUTZ, J. (2018) *Developmental Universities in Inclusive Innovation Systems: Alternatives for Knowledge Democratization in the Global South*. 1 ed. Londres: Palgrave Macmillan.
- AROCENA, R.; SUTZ, J. (2002) *Innovation Systems and Developing Countries*. DRUID Working Papers 02-05.
- AROCENA, R.; SUTZ, J. (2005) Latin American Universities: From an original revolution to an uncertain transition. *Higher Education*, n. 50, p. 573-592.
- AROCENA, R.; SUTZ, J. (2014) Innovación y democratización del conocimiento como contribución al desarrollo inclusivo. In DUTRÉNIT, G.; SUTZ, J. (Eds.) *Sistemas de Innovación para um Desarrollo Inclusivo*. cap. 1, p. 19-34.
- BERGEK, A.; NORRMAN, C. (2008) Incubator best practice: A framework. *Technovation* v. 28, p. 20-28.
- BORTAGARAY, I.; GRAS, N. (2014). Science, Technology, and Innovation Policies for Inclusive Development: Shifting Trends in South America. In: Crespi, G.; Dutrénit, G. (org.) *Science, Technology and Innovation Policies for Development: The Latin American Experience*, pp.255-285, Springer.
- BRAGA, T. M.; FREITAS, A. P. G.; DUARTE, G. S.; CAREPA-SOUZA, J. (2004) Índices de sustentabilidade municipal: o desafio de mensurar. *Nova Economia*. Belo Horizonte, v.14, no 3, p.11-33.
- BRITTO, J. N. P.; ALBUQUERQUE, E. M. (2002) Clusters industriais na economia brasileira: uma análise exploratória a partir de dados da RAIS. *Estudos Econômicos*. São Paulo: USP, v. 32, n.1, p. 71-102.
- BRUNDENIUS, C., LUNDVALL, B.-Å.; SUTZ, J. (2009) The Role of Universities in Innovation Systems in Developing Countries: Developmental University Systems - Empirical, Analytical and Normative Perspectives. In Lundvall, Joseph, Chaminade and Vang (eds) *Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Setting*, Cheltenham: Edward Elgar, 311-337.

- CAMPOS, R. R.; NICOLAU, J. A. (2003) Questionário e procedimentos para trabalho de campo da pesquisa de micro e pequenas empresas em arranjos produtivos locais. Research Report, RedeSist.
- CARAYANNIS, E. G.; BARTH, T. D.; CAMPBELL, D. F. J. (2012). The Quintuple Helix Innovation Model: Global Warming as a Challenge and Driver for Innovation. *Journal of Innovation and Entrepreneurship*, 1(1), 1-12.
- CARAYANNIS, E. G.; RAKHMATULLIN, R. (2014). The quadruple/quintuple innovation helixes and smart specialization strategies for sustainable and inclusive growth in Europe and beyond. *Journal of the Knowledge Economy*, 5(2), p. 212-239.
- CARRIÈRE, J-P; CAZELLA, A. A. (2006) Abordagem Introdutória ao Conceito de Desenvolvimento Territorial. *Eisforia, Florianópolis*, v.4, n. especial, p. 23-47.
- CASSIOLATO, J. E., MATOS, M. P., LASTRES, H. M. M. (2014). Innovation Systems and Development. In CURRIE-ALDER, B.; KANBUR, R.; MALONE, D. M.; MEDHORA, R. (Eds) *International Development Ideas, Experience and Prospects*, Oxford: Oxford University Press.
- CASSIOLATO, J. E.; LASTRES, H. M. M. (1999) Inovação, globalização e as novas políticas de desenvolvimento industrial e tecnológico. In: CASSIOLATO, J. E.; LASTRES, H. M. M. (org.). *Globalização e inovação localizada: experiências de sistemas locais do Mercosul*. Brasília: IBICT/MCT.
- CASSIOLATO, J. E.; LASTRES, H. M. M. (2005) Sistemas de inovação e desenvolvimento: as implicações de política. São Paulo: São Paulo Perspec., v. 19, n. 1, p. 34-45.
- CASSIOLATO, J. E.; LASTRES, H. M. M. (2018) Participação das Universidades e Instituições Públicas de Ensino e Pesquisa no Desenvolvimento Regional Sustentável. Research Report, RedeSist.
- CASSIOLATO, J. E.; LASTRES, H. M. M.; MACIEL, M. L. (2003) Systems of innovation and development: evidence from Brazil. Cheltenham: Edward Elgar.
- CASSIOLATO, J. E.; PODCAMENI, M. G.; SOARES, M. C. C. (2015). Sustentabilidade socioambiental em um contexto de crise políticas estratégicas de inovação e mudança estrutural. Rio de Janeiro: E- papers.
- CASSIOLATO, J.; LASTRES, H. M. M. (2008) Discussing innovation and development: Converging points between the Latin American school and the Innovation Systems perspective. *Globelics, Working Paper Series*, No. 08-02, Jan. 2008.
- CHATAWAY, J.; HANLIN, R.; KAPLINSKY, R. (2014) Inclusive innovation: an architecture for policy development. *Innovation and Development*, 4, 1, pp.33-54.
- COMISSÃO MUNDIAL SOBRE MEIO AMBIENTE E DESENVOLVIMENTO (1991) *Nosso futuro comum*. 2a ed., Rio de Janeiro: Fundação Getúlio Vargas, 1991.
- COZZENS, S.; SUTZ J. (2012) *Innovation in Informal Settings: A Research Agenda*, IDRC
- DAGNINO, R.; FONSECA, R. (2007) Economia solidária, incubadoras universitárias, cooperativas e tecnologia: uma definição de papéis. *Proposta*, 12 (31), 16-24.

- DUBEUX, A. M. (2007) O Papel das Universidades na Construção da Economia Solidária no Brasil. *Proposta*, 31(111), 4-15.
- DUTRÉNIT, G., SUTZ, J. (2017). Sistemas de innovación para un desarrollo inclusivo: la experiencia latinoamericana. Foro consultivo científico y tecnológico - Latics, Mexico.
- ETZKOWITZ, H. (2002) Incubation of incubators: innovation as a triple helix of university-industry- government networks. *Science and Public Policy*, vol. 29, n. 2, p. 115-128, Apri.
- FISCHER, B. B.; ZEITOUN, C.; SCHAEFFER, P. R. (2020) Metodologia de avaliação e classificação de parques tecnológicos do Brasil. Relatório Técnico apresentado à Secretaria de Desenvolvimento Tecnológico e Inovação do Ministério da Ciência, Tecnologia, Inovações e Comunicações. GEOPI, Departamento de Política Científica e Tecnológica, Unicamp.
- FONSECA, C. A. G. M. (2010) Índice de Sustentabilidade Municipal: um instrumento de avaliação da qualidade de vida nos municípios brasileiros. Dissertação de mestrado. Programa de Pós-graduação em Desenvolvimento Sustentável, Centro de Desenvolvimento Sustentável, Universidade de Brasília, 2010. Brasília: CDS/UNB.
- FREEMAN, C. (1982). Innovation and long cycles of economic development. In: International seminar on innovation and development at the industrial sector. Departamento de Economia da Universidade de Campinas, Campinas.
- FREEMAN, C. (1987). Technology policy and economic performance: lessons from Japan. Frances Pinter, London.
- GUIMARÃES, G. (2007) O Papel das Universidades na Construção da Economia Solidária no Brasil. *Proposta*, 31(111), 23-26.
- HARPER-ANDERSON, E.; LEWIS, D. A. (2018) What Makes Business Incubation Work? Measuring the Influence of Incubator Quality and Regional Capacity on Incubator Outcomes. *Economic Development Quarterly*, v. 32, n. 1, p. 60-77.
- INSTITUTO DE PESQUISA ECONÔMICA APLICADA - IPEA (2019) Objetivos de Desenvolvimento Sustentável. Rio de Janeiro: IPEA.
- JOHNSON, B.; ANDERSEN, A. D. (red.) (2012) Learning, Innovation and Inclusive Development: New perspectives on economic development strategy and development aid. Aalborg Universitetsforlag. Globelics Thematic Report Bind 2011/2012.
- KAPLINSKY, R. (2010). Schumacher Meets Schumpeter: Appropriate Technology Below the Radar." *Research Policy* 40 (2): 193-203.
- KIM, H-Y.; JUNG, C. M. (2010) Does a Technology Incubator Work in the Regional Economy? Evidence from South Korea. *Journal of Urban Planning and Development*, Vol. 136, No. 3, September.
- LA ROVERE, R. L.; MATOS, M. P. M. SANTOS, G. O.; LIMA, A. P. C. S. (2020) Bridging the literature on innovation systems and entrepreneurial ecosystems: Cross-fertilizations for understanding knowledge-intensive, social and environmental entrepreneurship. In: A. Tsvetkova; J. Schmutzler; R. Pugh (ed.). *Entrepreneurial Ecosystems Meet Innovation Systems: Synergies, Policy*

Lessons and Overlooked Dimensions; New Horizons in Regional Science series. Edward Elgar.

- LASTRES, H.M.M.; APOLINÁRIO, V.; CASTRO, S.D.; MATOS, M.P. (2021) Transformações e aprendizados da Covid-19 e a dimensão territorial da saúde: por uma nova geração de políticas públicas para o desenvolvimento. *Cadernos do Desenvolvimento*, vol. 16, n. 28, p. 87-114, jan.-jun.
- LASTRES, M. M.; CASSIOLATO, J. E.; MACIEL, M. L. (2004) *Pequena empresa: cooperação e desenvolvimento local*. Rio de Janeiro: Relume Dumará Editora.
- LUNDEVALL, B.-Å. (1985). *Product innovation and user-producer interaction*. Aalborg: Aalborg University Press.
- LUNDEVALL, B.A. (2007) *Innovation system research and policy: where it came from and where it might go*. CAS Seminar, Oslo, December 4.
- LUSTOSA, M. C. J.; PODCAMENI, M. G. VB.; MARCELLINO, I. S.; URTI, C. T.; ANDREATTA, A. C.
- QUEIROZ, J. M. (2017) *Desenvolvimento local, inclusivo e sustentável: revisitando a sustentabilidade a partir da perspectiva sistêmica de arranjos produtivos locais*. In: MATOS et al. (orgs.) *Arranjos Produtivos Locais: referencial, experiências e políticas em 20 anos da RedeSist*. Rio de Janeiro: E-Papers.
- MACÊDO, N. M. M. N.; CÂNDIDO, G. A. (2011) Índice de Desenvolvimento Sustentável Local e suas influências nas políticas públicas: um estudo exploratório no município de Alagoa Grande - PB. *Revista de Gestão Social e Ambiental - RGSA*, São Paulo, v. 18, n. 3, pp. 619-632.
- MARCELLINO, I. S.; ROCHA, P.; LASTRES, H. M. M.; CASSIOLATO, J.; APOLINÁRIO, V. (2020) Análise Multidimensional da Relação Universidade-Sociedade no Brasil: interação entre a Incubadora Tecnológica de Cooperativas Populares da Universidade Federal do Rio de Janeiro (ITCP/UFRJ) e as cooperativas de catadores de material reciclável. In _____. *Caminos hacia la transformación*, cap 7, no prelo.
- MARTINS, M. F.; CÂNDIDO, G. A. (2012) Índices de Desenvolvimento Sustentável para Localidades: uma proposta metodológica de construção e análise. *Revista de Gestão Social e Ambiental*. São Paulo, v. 6, nº 1, p. 03- 19.
- MATOS, M. G. P.; CASSIOLATO, J. E.; PEIXOTO, F. (2017) O referencial conceitual e metodológico para a análise de Arranjos Produtivos Locais. MATOS et al. (orgs.) *Arranjos Produtivos Locais: referencial, experiências e políticas em 20 anos da RedeSist*. Rio de Janeiro: E-Papers.
- MATOS, M. P.; BRAGA, K.; ALMEIDA, L. A.; ROCHA, P. C. (2020) *Políticas de Inovação para Microempresas (ME) e Empresas de Pequeno Porte (EPP) no Brasil e em países selecionados. Relatório Final da pesquisa Desenvolvimento de Capacidades Institucionais para Ampliação e Modernização dos Processos de Formulação, Implantação e Avaliação das Políticas em Ciência, Tecnologia, Inovação e Comunicações*. RedeSist, IE/UFRJ.
- MATOS, M. P.; LUSTOSA, M. C. J.; ROCHA, P. C.; ALMEIDA, L. A.; MOLL, B. S. (2021) *Sistemas Produtivos e Inovativos Locais como Ponte entre Incubadoras e Parques Tecnológicos e o Desenvolvimento Regional e Local*. Research Report, MCTI.

- MCADAM, M.; MILLER, K.; MCADAM, R. (2016) Situated regional university incubation: A multi-level stakeholder perspective. *Technovation*, Vol. 50-51, p. 69-78, April-May.
- MCTI / ANPROTEC (2019) Mapeamento dos mecanismos de geração de Empreendimentos Inovadores no Brasil. Brasília: Anprotec. Available at: https://anprotec.org.br/site/wp-Content/uploads/2019/09/Mapeamento_Empreendimentos_Inovadores.pdf.
- MCTIC / ANPROTEC (2019) Mapeamento dos mecanismos de geração de Empreendimentos Inovadores no Brasil. Brasília: Anprotec. Available at: https://anprotec.org.br/site/wp-Content/uploads/2019/09/Mapeamento_Empreendimentos_Inovadores.pdf.
- MCTIC / UFV (2019) Mapeamento de Parques Tecnológicos divulgado na plataforma Inovadatabr. BRASIL, 4 mar.
- MCTIC / UNB (2019) Estudo de Projetos de Alta Complexidade: Indicadores de Parques Tecnológicos. BRASIL.
- MIAN, S. (1996) Assessing value-added contributions of university technology business incubators to tenant firms. *Research Policy*, Volume 25, Issue 3, p. 325-335, May.
- MIAN, S. (1997) Assessing and managing the university technology business incubator: an integrative framework. *Journal of Business Venturing*, v. 12, p. 251-285.
- MIAN, S.; FAYOLLE, A.; LAMINE, W. (2012) Building sustainable regional platforms for incubating science and technology businesses: Evidence from US and French science and technology parks. *Entrepreneurship and Innovation*, Vol. 13, N. 4, p. 235-247.
- MIAN, S.; FAYOLLE, A.; LAMINE, W. (2016) Technology Business Incubation: An overview of the state of knowledge. *Technovation*, Vol. 50-51, p. 1-12, April-May.
- NUNES, M. A.; GARCIA, R. A; FERREIRA, R. N. (2019) Mensuração do Grau de Sustentabilidade dos Municípios Brasileiros: a condição dos municípios recém-criados frente aos municípios progenitores. XXI Encontro da Abep, Anais.
- OECD (1997) Technology incubators: nurturing small firms. p. 4-32, Paris.
- OLIVEIRA, J. BAGATINI F. M.; BARICHELLO, R.; RODRIGUES, M. P.; HABAS, R. F. (2017) Parques tecnológicos: alavancagem econômica do entorno. *Revista Produção e Desenvolvimento*, v.3, n.3, p.43-54, dez.
- PECQUEUR, B.; PEYRACHE-GADEAU, V. (2010) Fondements Interdisciplinaires et Systémiques de l'approche territoriale: introduction. *Revue d'Économie Régionale & Urbaine*, n.4, p. 613-662.
- PODCAMENI, M. G.; CASSIOLATO, J. E.; LUSTOSA, M. C.; MARCELLINO, I.; ROCHA, P. (2019) Exploring the convergence between sustainability and local innovation systems from a southern perspective: What Brazilian empirical evidence has to offer. *Local Economy*, v. 34, n. 8, p. 825-837.
- POONJAN, A.; TANNER, A. N. (2018) Science and Technology Parks and Regional Contextual Factors: A Systematic Literature Review preliminary study. Paper

- presented at EU-SPRI Early Career Conference Public R&D funding and evaluation: Methods, Trends and Changes, Rome.
- PROTEC - Universidade Federal do Amazonas (2021) Parque Científico e Tecnológico para a Inclusão Social. Available at: <<https://www.protec.ufam.edu.br/menu10item01.html>>
- RÉUS, I.; ANDION, C. (2018) Gestão Municipal e Desenvolvimento Sustentável: panorama dos indicadores de sustentabilidade nos municípios catarinenses. *Revista Desenvolvimento em Questão*. Ijuí- RS, v. 16, nº 45, p. 97-117.
- SACHS, I. (2009) Caminhos para o desenvolvimento sustentável. Rio de Janeiro: Garamond.
- SANT'ANNA, N. C. R. (2017) Índice de Performance da Sustentabilidade nova proposta metodológica para a avaliação socioeconômica e Municipal: uma ambiental dos municípios brasileiros. Dissertação de mestrado. Programa de Pós-graduação em Desenvolvimento Sustentável, Centro de Desenvolvimento Sustentável, Universidade de Brasília. Brasília: CDS/UNB.
- SEN, A. (1999) *Development as Freedom*. Cambridge: Oxford University Press.
- SENTANA, E. GONZALEZ, R.; GASCO, J.; LLOPIS, J. (2016) The social profitability of business incubators: a measurement proposal. *Entrepreneurship & Regional Development*, 29(1-2), pp.1-21.
- SOARES, M. C. C.; CASSIOLATO, J. (2013) Innovation systems and inclusive development: some evidence based on empirical work. paper submitted to an international workshop on new models of innovation for development, University of Manchester, July. Available at http://hummedia.manchester.ac.uk/institutes/cdi/news_and_events/SoaresCassioloPreWorkshopPaper.pdf
- SOARES, M. C. C.; SCERRI, M.; MAHARAJH, R. (2013) *Development Challenges in BRICS: Inequality and National Innovation Systems*, India, Routledge.
- SOUZA, L. C. L.; MATOS, I. M. A.; PETER, M. G. A.; MACHADO, M. V. V.; NASCIMENTO, C. P. S. (2013) Índice de Desenvolvimento Sustentável para Municípios (IDSM): um estudo sobre o nível de sustentabilidade das capitais brasileiras. *Engema, Annals*, 2013.
- STORPER, M. (1997) Territorialization. In: COX, K. R. *Spaces of Globalization: Reasserting the Power of the Local*, Guilford Publications.
- SUZIGAN, W. (2006). Identificação, mapeamento e caracterização estrutural de arranjos produtivos locais no Brasil. Brasília: Instituto de Pesquisa Econômica Aplicada.
- VASCONCELOS, A. C. F.; CÂNDIDO, G. A. (2013) Índice de Desenvolvimento Sustentável Municipal Participativo: uma aplicação no município de Cabaceiras - PB. *Revista Capital Científico*. Guarapuava - PR, v.9, nº 2, p.83-97, 2011. São Paulo, XV Engema, Annals.
- VELHO, L. (2007) O Papel da formação de pesquisadores no sistema de inovação. *Ciência e Cultura*, v.59, n.4, p. 23-28, São Paulo.
- VIEIRA, P. F. (2003) Rumo ao Desenvolvimento Territorial Sustentável: esboço de roteiro metodológico participativo. *Esforia. PPGAGR*, Florianópolis, v.1, n.1, p. 249-309.

VIEIRA, P. F; CAZELLA, A.A.; CERDAN, C. (2006) Desenvolvimento territorial sustentável: conceitos, experiências e desafios teórico-metodológicos. *Eisforia*, Florianópolis, v.4, n. especial, p. 13-20

Notes

¹ RedeSist is an interdisciplinary research network, formalised since 1997, based at the Institute of Economics of the Federal University of Rio de Janeiro with focus on Innovation System and regional/local development research (<http://www.redesist.ie.ufrj.br/>).

² For example, the criteria used for selecting companies and prioritizing production systems may be proved by documentation of previous calls for proposals. Formal agreements and covenants may be proved by means of the documents that formalize such relations. Actions and incentives direct towards supported companies may be proven through institutional material, among others.

³ MCTIC; ANPROTEC (2019); MCTIC; UNB (2019); MCTIC; UFV (2019)

⁴ The sample calculation proposed by Campos and Nicolau (2003) was used as reference: $n = (N \cdot no) / (N + no - 1)$, where N corresponds to the population, n to the sample and $no = 1 / Eo^2$, where Eo is the tolerated sampling error. A confidence level of 95% was used

⁵ Appendix 1 presents the system of questions and construction of indicators for technology parks

For the construction of the indices referring to the dimensions of sustainability, we started from the literature review on municipal indicators of sustainable development (Braga et al. 2004; Fonseca 2010; Martins and Cândido 2012; Nunes et al. 2019; Réus and Andion 2018; Sant'Anna 2017; Souza et al. 2013; Vasconcelos and Cândido 2013). Special emphasis was given to Sachs' (2009) definition of sustainability, as explained in the section above. For each dimension of sustainability, several statistics available in official databases were collected (for details, see Matos et al. 2021).

The values of the variables were normalized so that the minimum value (as the worst possible situation) is 0 (zero) and the maximum value (as the best possible situation) is 1 (one). Next, the sustainable development index is used to qualify the answers to question 1.1 of the questionnaire, according to the following calculation:

Score per sustainability dimension:

$$r_{i,g}^s = \frac{1}{m} \sum_{p=1}^m p_{i,g}^s$$

where $r_{i,g}^s$ represents the responses of the organization i , situated in region g , to the options in question 1.1 that are associated with sustainability dimensions and m is the number of options associated to each dimension.

Convergence index per sustainability dimension:

$$D_{i,g}^s = \begin{cases} \frac{1}{2} \left(\frac{r_{i,g}^s - F_{i,g}^s}{F_{i,g}^s} \right) & \text{if } r_{i,g}^s > F_{i,g}^s \\ \frac{1}{2} \left(\frac{F_{i,g}^s - r_{i,g}^s}{F_{i,g}^s} \right) & \text{if } r_{i,g}^s \leq F_{i,g}^s \end{cases}$$

where $D_{i,g}^s$ is the indicator of the degree of development of region g per sustainability dimension S .

Thus, the organization scores if it assigns high importance to a sustainability dimension, even if this dimension does not constitute a relevant challenge of the region ($D_{i,g}^s > F_{i,g}^s$). But if the dimension constitutes a substantial challenge for the region, the innovation

environment scores also according to how great the difference between the importance assigned $F_{i,g}^s$ and the degree of development in such dimension $D_{i,g}^s$ is.

The summary indicator is obtained by summing the indices per dimension of sustainability, the maximum being equal to 1.

First we calculated the degree of relative specialisation of each region in different Production Systems, following a methodology inspired by Britto and Albuquerque (2002) and Suzigan et al. (2006), but constituting an adapted locational quotient, more sensitive to the diversity of local productive structures (for details, see Matos et al. 2021). Then the convergence index is calculated, given by:

$$C_{i,g}^j = \frac{r_{i,g}^j}{\sum_{j=1}^J r_{i,g}^j} \cdot \left(\frac{I_{i,g}^j}{F_{i,g}^j} \right)$$

where $C_{i,g}^j$ is the convergence index of the organization i located in region g , $I_{i,g}^j$ is the degree of importance of the production system j in region g , $F_{i,g}^j$ informs whether the organization i , located in region g , focuses on this production system j (=1 if yes and =0 if no).

The Role of Innovation in Humanitarian Assistance – A Systematic Literature Review

Maximilian Franz Georg Bruder, Thomas Baar
UNU-MERIT, Netherlands

Abstract

The promise of innovation in humanitarian contexts has generated an expanding literature, from academics as well as practitioners. However, the field has become characterised by conceptual ambiguity and insular approaches, inhibiting the integration of findings and best-practices. Therefore, this paper aims to identify the key concepts, definitions, and themes in humanitarian innovation (HI) research by applying a systematic literature review and content analysis. Based on data from 301 publications, we analyse scholarly and practitioner articles addressing the topic of humanitarian innovation. Our analysis suggests that efforts to reform the humanitarian system by leveraging innovation have been primarily ad-hoc, fragmented, and serving miscellaneous separate objectives. This results in the implementation of incremental improvements, rather than transformative change throughout the sector. To bridge the gap between the various conceptualisations of HI, we propose a conceptual framework that provides a system perspective on HI, which includes the institutions, actors, contextual factors, and outputs of the system. The implications of our finding for further research and policy are discussed as well.

Key Words: Humanitarian Innovation, Innovation Systems, Systematic Literature Review

1. Introduction

There is a rising operational and financial deficit in the capacity of governments and humanitarian organisations to respond to humanitarian needs, as challenges facing international humanitarian action are growing in scale, scope, and complexity. While absolute funding for humanitarian relief has been continuously increasing, it is not able to keep up with the growing requirements, as assessed by Humanitarian Response Plans (HRPs) for different regions and countries (OCHA, 2022). This situation has been compounded by the global coronavirus pandemic, which created enormous demand at the same time limited the availability and mobility of human, physical, and financial resources (Ramalingam et al., 2020). Additionally, the war in Ukraine led to a grave humanitarian crisis in the country itself and its ripple effects are felt in the global food and energy markets (OCHA, 2022). Overall, In 2022, 274 million people need humanitarian assistance and protection, a significant increase from 235 million people in 2021, which was already the highest figure in decades (OCHA, 2022).

Given the increasing needs, and the pressure on the scarce resources available to address them, there has been a recognition within the humanitarian sector of the necessity for radical change to deliver better aid (Chandran, 2015; Finnigan & Farkas, 2019; Ramalingam, 2013; The Guardian, 2016). Consequently, over the past decade, the humanitarian sector has begun investing more heavily in innovation, seeking new and more efficient solutions to humanitarian crises, to narrow the funding gap in the sector. Yet, while ‘innovation’ has become a prominent concept in the humanitarian sector, a counternarrative has formed that decries innovation’s seeming inability to bring about transformational change in the sector. Fundamentally, it is unclear to what degree humanitarian innovation (HI) has had a positive impact on humanitarian practises and whether it can achieve transformative change. Furthermore, the discussion around the subject is presently fragmented, lacks conceptual clarity, and fails to coherently identify the most potent levers for impact. We therefore ask the research question

What is the state of the art of humanitarian innovation?

This question is split into several sub-questions:

- How has the literature on humanitarian innovation evolved since 2015?
- How is (successful) innovation in different contexts of humanitarian assistance being defined by different actors?
- Which innovations are being introduced into humanitarian contexts?
- Which sectors are most affected by humanitarian innovation?
- Which types of innovations are introduced?

- Who is the primary target of humanitarian innovation?
- Which strategies are applied in managing humanitarian innovation?
- What are the primary themes / factors impacting innovation performance?

Hence, the purpose of this article is to review both the academic and practitioner literature to assess how the concept of humanitarian innovation has been applied and has evolved over time. This includes identifying definitions of key concepts, the characteristics of the innovations in humanitarian contexts, as well as their level of success. Further, the study synthesises factors impacting the performance of humanitarian innovation, thereby outlining trends and leverage points that can be used to improve the innovation outputs in the humanitarian system.

We make several contributions in this article. First, we provide a systematic review of articles building on the humanitarian innovation concept, which allows us to comprehensively outline the state of the art on humanitarian innovation thinking. Second, the authors propose a framework portraying innovation in humanitarian contexts as an innovation system, describing the main components of the humanitarian innovation system, in order to structure the discussion of findings and identify underexplored areas and connections. This framework can provide a basis for the continuing scholarly exploration of innovation in humanitarian contexts. Third, based on the existing literature, the article outlines possibilities for policymakers to contribute to innovation in the humanitarian sector.

The remainder of the article is structured as follows: The background section briefly describes the current state of the humanitarian sector and the role of innovation. The third section describes the methodology applied in conducting this systematic review. Section four offers a meta-description of the broad characteristics of humanitarian innovation research that emerge from the review, including the chronology, outlets, methods, and focus areas of the articles. Section five outlines the conceptual findings from the literature, specifically key definitions of innovation concepts. Section six examines practical findings, meaning the characteristics of innovations introduced in the field. Section seven presents a synthesis of the main factors impacting humanitarian innovation performance. Section eight discusses the findings and presents a unified comprehensive framework focussing on humanitarian innovation from a systems perspective, which ties together our findings. Section nine concludes, discusses the limitations of the research, and proposes avenues for future research.

2. Background

Humanitarian needs continue to grow and despite increasing levels of absolute funding, the gap between requirements and funding is more than \$32.9 billion, which is greater than ever (OCHA, 2022). Further, it is recognised by

humanitarian actors that humanitarian tools and services are in many cases ill-suited to modern emergencies, which are frequently prolonged and conflict-driven (Betts & Bloom, 2014). As a result, pressure has built to fundamentally alter the way humanitarian aid is provided, and innovation is considered a vehicle for introducing such change. The systematic application, study, and implementation of innovation is a recent phenomenon in the humanitarian field (Warner, 2017).

In 2008, the concept of humanitarian innovation was first introduced by the Active Learning Network for Accountability and Performance in Humanitarian Action (ALNAP). It began with an innovation fair at ALNAP's 25th annual meeting, showcasing 23 'real-world examples of innovations that have helped to change the way in which humanitarian action is delivered' (Scott-Smith, 2016). Within a few years the concept began to make waves at other institutions. For instance, the UK Department for International Development (DFID) announced a £3 million investment in innovation in the humanitarian system, the World Food Programme and the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) set up their own innovation grants, and similar initiatives were established at the United Nations Refugee Agency (UNHCR) and the International Committee of the Red Cross (ICRC) (Betts & Bloom, 2014). The concept became truly mainstream in 2016, when innovation was designated as one of the main themes for the World Humanitarian Summit (WHS). "To innovate", the WHS (2016) declared, "means to do things in new or better ways". That same year, the UN Agenda for Humanity stated that to deliver collective outcomes, the humanitarian sector must focus strongly on innovation (UN, 2016). This has been noted as a defining moment for HI, as it was followed by an increased interest in, and funding of, activities, publications and projects targeted at innovation (Scott-Smith, 2016). Consequently, a range of humanitarian actors have engaged in the "innovation turn", adopting innovation processes to stimulate new thinking on the provision of humanitarian assistance (Ramalingam et al., 2009). With the increased diffusion of the concept, there has also been an increase in differing conceptualisations of how humanitarian innovation is defined and conceptualised.

The field's burgeoning growth is related to the sector's perceived need to "do more with less", as innovation in the humanitarian context is often conceptualised with a strong link to cost-effectiveness and efficiency. Müller and Sou point out that because of this conceptualisation, the focus on innovation in relation to humanitarianism is heavily skewed towards technical fixes and new products' (2019). Technology has opened the doors for new practices in humanitarian action, with cutting-edge technologies such as big data, unmanned aerial vehicles (UAVs), 3D printing, digital currency, or the Blockchain initially had been ascribed the role of silver bullets. More recently, there has been an increasingly vocal dismissal of what is deemed humanitarian technophilia and a call for more holistic approaches. The tide of "optimism,

bordering on technological determinism” (Garman, 2015: 440) regarding humanitarian innovation, is considered by some as too restrictive a conceptualization and a call for more holistic approaches has materialised.

Furthermore, HI has been criticised for being too top-down and Northern biased, promoting externally developed solutions to perceived needs, rather than locally identified solutions rooted in end-users’ needs and priorities (Fejerskov & Fetterer, 2020; Sandvik, 2017). This has been called the top-down world of HI (Betts & Bloom, 2013), where actors from the Global North, such as private actors and international non-governmental organisations (INGOs), are influencing funding and decision making (Skeels, 2020). In order for HI to reach its full potential of meeting the growing challenges and enhance the efficiency and effectiveness of the humanitarian system in a sustainable manner, some have raised the need to localise HI (Fejerskov & Fetterer, 2020), stating that the innovation agenda “should have as its guiding light the idea of a paradigmatic shift in attitude, enabled by the principles of disaster prevention, local ownership and beneficiary engagement” (Ramalingam et al., 2009:81).

The introduction of humanitarian innovation was initially considered a turning point towards better delivery of timely, needs-based, effective, principled, and high-quality humanitarian assistance. However, over the years, debates have emerged, approaches and definitions have evolved, and the very idea that HI can deliver paradigmatic change is being questioned. Our review of the literature therefore aims to assess how the concept is currently applied and has evolved over time and review the key themes that have emerged in the concept.

3. Methodology

In this article, we combine the systematic literature review (an all-encompassing review of the available literature) with the inductive content analysis (an in-depth analysis of this literature's nature). A Systematic Literature Review (SLR) was conducted to map existing evidence on innovation humanitarian assistance and its impact on achieving humanitarian objectives. The utilisation of a systematic review methodology prevents the selection of randomly gathered publications, which would not be representative of the scholarship and practitioner literature building on the humanitarian innovation concept. We selected the articles to be included in the review through a systematic multi-stage procedure, following the standard steps of the Preferred Reporting Items for Systematic Reviews and Meta- Analysis (PRISMA) statement¹. This resulted in 301 articles published in academic and practitioner journals, as well as reports published by national governments. The analysis includes articles published between 2015 and 2021. Following article selection, the content of the articles was analysed and codified to identify relevant definitions, as well as practical and thematic insights.

The following subsection describes how the authors proceeded, providing the number of selected and discarded articles at each stage of the procedure, along with the selection criteria. A second subsection outlines the coding procedure used to standardise and cluster the information contained in the articles.

3.1. The Article Search and Selection Strategy

The authors selected the first set of potential articles by performing a keyword search for academic articles in SCOPUS, Web of Knowledge and Google Scholar and a keyword search for practitioner literature in Reliefweb. SCOPUS, Web of Knowledge and Google Scholar are the major databases for published academic articles, while Reliefweb is the most expansive database focusing on humanitarian practice, containing practitioner literature, government reports, and gray literature on humanitarian affairs. The keywords used were “humanitarian innovation” for the academic databases and “innovation” for Reliefweb, as all articles are concerned with humanitarian efforts. The time frame chosen is from 2015 to 2021, when the concept of humanitarian innovation entered the mainstream.

The first search step on these four databases using the key term “humanitarian innovation” or “humanitarian” and “innovation”, from the years 2015-2021, yielded the following results.

	SCOPUS	Web of Knowledge	Google Scholar	Reliefweb
URL	www.scopus.com	knowledge.com	https://scholar.google.com/scholar	reliefweb.int/updates
Search Term / Rule	TITLE-ABS-KEY (humanitarian AND innovation) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015)	TS= (humanitarian AND innovation*) Indexes=SCI - EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=2015-2021	"humanitarian innovation" FROM 2015	ANYWHERE: (innovation)2016 TO PRESENT, ANY LANGUAGE, ANY FORM further filtered by FORMAT 'analysis' OR Assessment OR Data OR Evaluation and Lessons Learned OR SituationReport OR UN Document

Number of Results	330	446	1070	481

Table 1: Databases for Article Selection

The keyword-based search for “humanitarian innovation” returned 330 results in SCOPUS, 446 in Web of Knowledge and 1070 in Google Scholar. The different number of results between the two databases may be explained by the different set of journals being available in each database and/or using a different search engine in each database. The search for “innovation” in Reliefweb returned 481 results. We complemented our search of large-scale databases with purposeful sampling from smaller, high-impact, databases e.g., government websites, UN websites, practitioner websites such as Elrha, etc, which we searched using the same keywords. We thereby further increased our preliminary sample by 257 articles. Several articles considered as seminal in the field that were published before 2015 were also included.

From this initial corpus of 2584 articles, we removed all article duplicates, thereby excluding 981 articles. Hence, for the 1603 articles, we screened the titles and abstracts and excluded them if any of the following exclusion criteria were met:

- Non-valid formats (e.g., letters, Master Theses, Entire books, lectures, course descriptions)
- False positive (humanitarian): Meaning of the word ‘humanitarian’ does not refer to ‘the sector’ (i.e. it describes a sentiment, or a subset of health care, etc.)
- False positive (innovation): ‘innovate’ or ‘innovative’ or ‘innovation’ is mentioned as a passing reference/use of an adjective/ innovation, non-specific.
- Concept mismatch: While the terms “humanitarian” and “innovation” are both occurring in the article, they are not used in combination as “humanitarian innovation”
- Method mismatch: Has no humanitarian application (e.g., biographical, or related research whose product is journalistic or historical).

The abstract screening eliminated a further 1097 articles, leaving us with 506 for full text review. In the final stage of the selection procedure, we fully read the remaining 506 articles identified. An additional 205 articles were removed upon reading because the content of the article was not directly related to humanitarian innovation. This reading led to a final set of 301 articles being selected for article coding

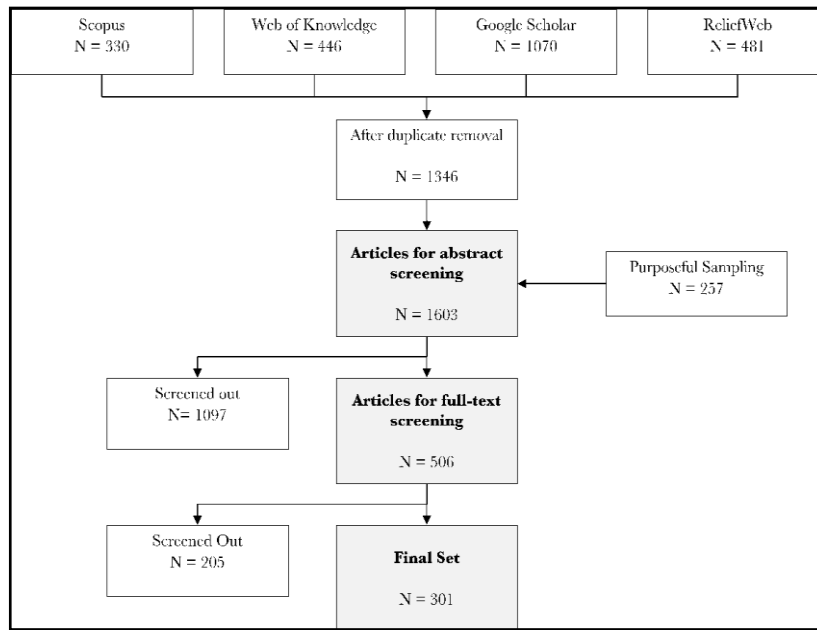


Figure 1: The Article Selection Process

3.2. The Coding Procedure

From the final selection of articles, we analysed four different data types, described in the table below.

1. Metadata information – meaning metadata about the articles
2. Conceptual information – meaning the key concepts and definitions applied for humanitarian innovation
3. Practical information – meaning the characteristics of innovations employed in the humanitarian contexts
4. Thematic information – meaning the concepts related to humanitarian innovation used in the articles and the conclusions drawn by the authors as to how to advance the HI agenda

#	Data Type	Data Type description	Information Obtained
1	Metadata	Data providing information about the data itself	The type of article (academic or practitioner)
			The publication year
			The applied research method
			scope of the article, including subject and industry focus

2	Conceptual Data	Concepts and definitions applied to humanitarian innovation	The definition of humanitarian innovation given in the texts
			The stated objective of humanitarian innovation (i.e. how success is defined)
3	Application Data	The characteristics of innovations applied in the humanitarian contexts	The stated objective of humanitarian innovation (i.e. how success is defined)
			Innovation Sectors – the sector to which the humanitarian innovation belongs
			Innovation Types - the typification of innovations
			Innovation Target – the envisioned end-users of an innovation
			Innovation Management Strategy - the different approaches of how innovation development, coordination, and diffusion are managed within the sector
4	Thematic Data	The key themes present in the research articles on the factors impacting humanitarian innovation performance	Drivers and Obstacles of Humanitarian Innovation, meaning factors which enable or pose risks to the flourishing of humanitarian innovation

Table 2: Data Types and Information Obtained from the Literature

We coded each article and incorporated the results into a database to standardise the information contained in the articles and to facilitate the identification of trends in the literature. Overall, we coded ten properties of the articles, in line with the categories described above. All authors and three research assistants were conducting the coding and the respective coding of articles was cross-checked for a sample of articles, in order to ensure alignment of the individual understanding of the meaning of each category's meaning.

For the article coding, we employed a content analysis approach, whereby we developed inductive categorisations of the matters of concern, as opposed to applying preconceived notions (Hsieh & Shannon, 2005). We organised the content analysis based on an inductive, bottom-up identification of topical categories. To generate the categories, we independently sketched and clustered into topics a list of descriptors taken from the text. Subsequently, we compared and merged the resulting classifications into typologies, which are described in the findings sections.

The Appendix presents a complete list of the 301 articles identified in the review.

4. Data Description

In the literature, we identified several different types of output. Many articles focus on offering conceptual advice on strategy for practitioners and policymakers to transform humanitarian practice and create the necessary prerequisites to make it “innovation-ready”. Another group of articles reports on (individual) cases of humanitarian innovation initiatives and their outcomes, mainly to describe products and services considered to be suitable for the context by the authors. However, there is only a small number of articles that rigorously evaluates innovations’ impact ex-post, with most articles describing potential outcomes of innovations yet to be introduced in the field, or only so far having been piloted. On a smaller scale, some articles are devoted to the evaluation and critique of humanitarian innovation ideas and initiatives overall, offering critique or endorsement of the concept of innovation in humanitarian contexts.

4.1. The Chronology of Humanitarian Innovation Research

Bessant et al. note that “the humanitarian sector is a relative newcomer to innovation, in terms of both practices and literature. There were no publications focused on the subject until 2009, making humanitarian innovation literature around a century younger than the overall innovation management field” (2014, 24). Although some articles on the concept of HI were published between 2009 (when the term humanitarian innovation was coined) and 2015, the concept did not take off until it was deemed a priority in the 2015 World Humanitarian Summit. Prior to the so-called “innovation turn”, the humanitarian sector attracted little attention from academic innovation studies researchers. Only more recently, practitioner and academic literature have begun displaying a growing number of studies on the potential of humanitarian innovation, describing new projects, processes, and approaches for improving humanitarian aid; addressing funding, budgeting, and institutional support; exploring the challenges of developing use cases and evidence-based practices; and the difficulty of bringing innovations to scale.

The chronology of the articles studying humanitarian innovation is presented in Figure 2. The number of articles on humanitarian innovation has overall been increasing since 2015, indicating the concept’s persistent and mounting relevance for the sector

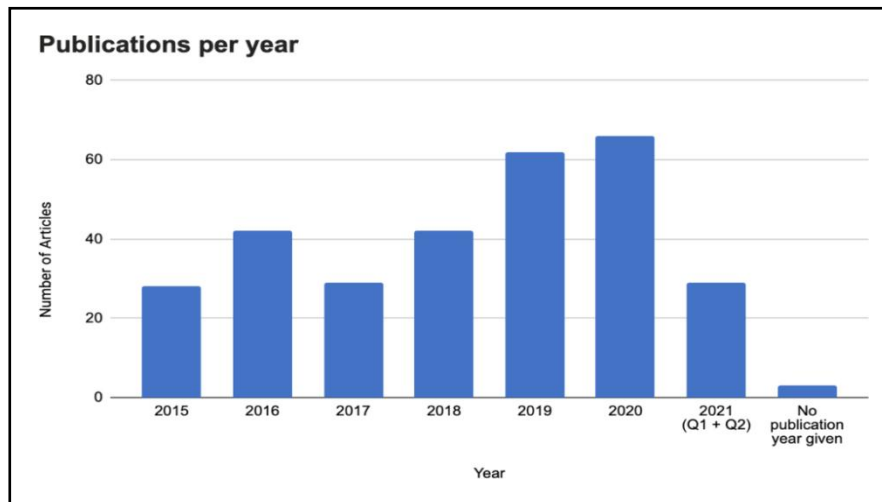


Figure 2: Academic Publications on Humanitarian Innovation

4.2. Types of Research on Humanitarian Innovation

For the systematic literature review, we considered both academic and practitioner literature, to cover the entire spectrum of work on humanitarian innovation. We differentiate academic from practitioner literature by the type of review they undergo. Academic articles are those which undergo a process of peer review prior to publishing, whereas practitioner literature is generally self-published through an institution and no peer review is conducted.

A review of the outlets of the 301 humanitarian innovation articles finds that 188 are published in practitioner-oriented outlets and 113 in outlets targeting academics. The three outlets with the highest count of publications, totalling 51, are all aimed at practitioners (Elrha, OCHA, UNHCR). The academic outlets most represented are the journals “Conflict and Health”, the “Journal of Humanitarian Logistics and Supply Chain Management” and the “Journal of International Humanitarian Action”, for a total of 15 publications.

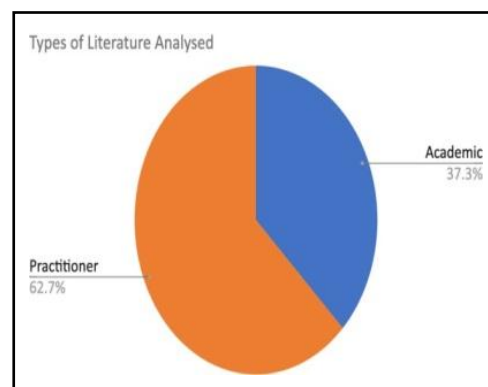


Figure3 Types of Literature Analysed

The asymmetry in the number of articles published in the two types may reflect a preference of humanitarian innovation researchers for articles with direct application among practitioners. It might also be due to the type of studies prevalent in humanitarian innovation articles, including case studies, narratives, or studies with limited theoretical contributions, which may prove more difficult to publish in academic journals.

Furthermore, in the literature, we observe an overwhelming majority of qualitative research. The lack of data driven analysis and quantitative research methods may further impede publications being placed in academic journals.

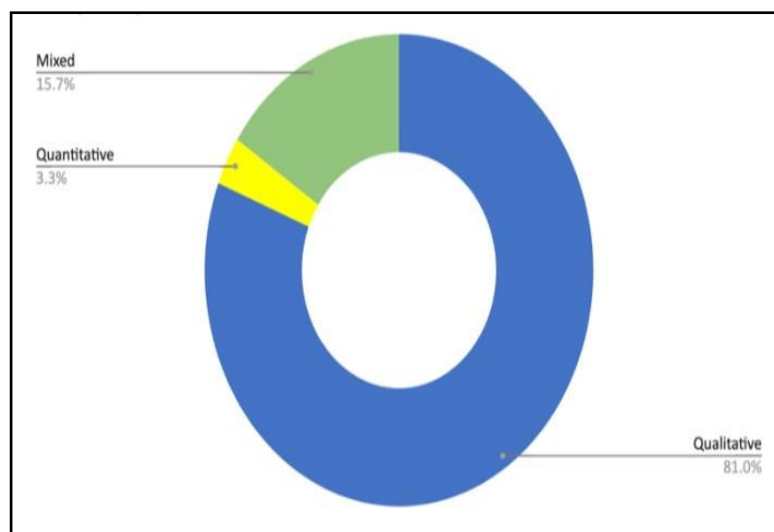


Figure 4: Types of Research in the Analysed Literature

4.3. Focus Areas of the Articles

The articles within the corpus of literature focus on different subject areas in relation to humanitarian innovation. The following figure presents the frequency of certain focus areas across the entire corpus.

The most frequently covered theme across the corpus is Technology & Telecommunications. This indicates the focus on the role technology plays in innovation. Access is the second most frequent focus area, relating to the ongoing challenge of humanitarian practitioners to access affected populations more efficiently and effectively and deliver necessary goods and services. Other frequently mentioned areas include capacity development, health, financing, and coordination. Besides such areas of application, considerable attention is also given as to how innovation should be conducted, referring to the innovation process itself, as is manifest from the frequency in which articles discuss issues such as collaboration, ethics, and evidence, partnerships, and private sector engagement. Certain topics are clearly more trend-related such as demonstrated by the recent focus on COVID-19 in humanitarian innovation literature since 2020.

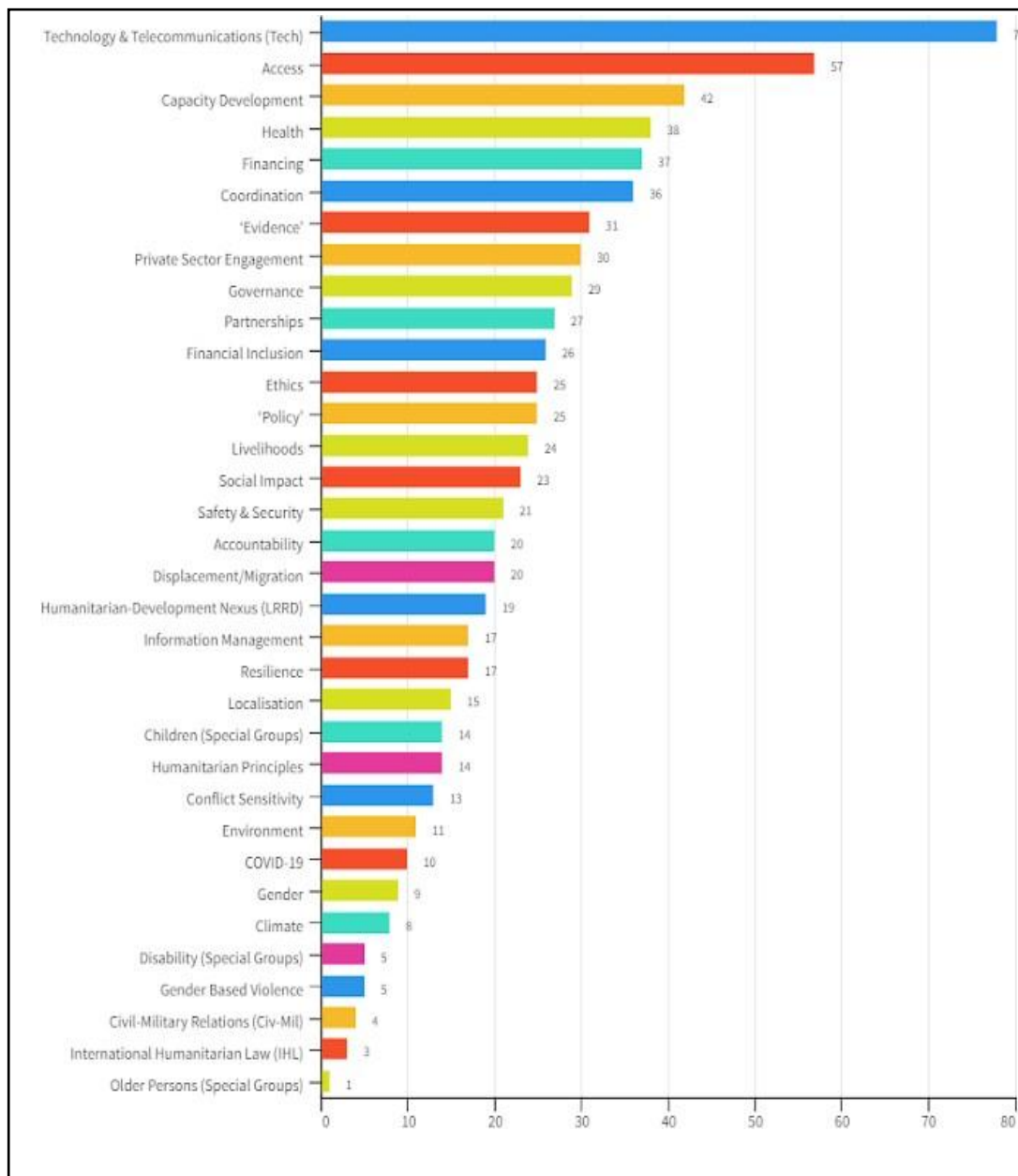


Figure 5. Focus Areas of Humanitarian Innovation Literature (articles can relate to two or more topics)

5. Conceptual Findings

5.1. Definitions of Humanitarian Innovation

Although there has been a considerable increase in literature in recent years, most articles we analysed do not define the terms “innovation” or “humanitarian innovation”, with only 25% giving any kind of definition or stating the purpose of innovation in the humanitarian context. This is

symptomatic of the sector, where a common definition or a common language for humanitarian innovation more generally is still missing.

Some articles defining humanitarian innovation do not specifically tailor the definition to the humanitarian context. For instance, Scott-Smith defines it simply as a ‘means to do things in new or better ways’ (2016, 2). Bounie et al. label it “incremental improvements” (2020, 370), and Krishnan (2020) indicates how innovative solutions encourage new ideas and products to tackle real-time problems. The Swedish Cooperation Agency, Sida, defines it as ‘the use of knowledge – ideas, technologies, and processes – into products, procedures and services that bring added value and are new in a specific context’ (2015, 5). The concept of innovation can be applied to almost all specialised areas and may include technology, but it is not reducible to technology. Furthermore, as OCHA notes, innovation should not be confused with invention: ‘Innovation does not require the creation of something novel, it may also include the adaptation of something existing to a different context. Furthermore, there is no threshold for change to qualify as innovative, as it includes both disruptive as well as incremental innovations’ (Betts & Bloom, 2014, 5-6). These relatively broad and practical meanings contrast starkly with that used by the single largest donor, the United States Agency for International Development (USAID), which fuses humanitarian and development approaches, referring to innovation as ‘novel business or organisational models, operational or production processes, or products or services that lead to substantial improvements (not incremental “next steps”) in addressing [humanitarian] challenges’ (2020, 4).

Some practitioners extend these notions by specifying the purpose of innovation and placing it in the humanitarian context. The Humanitarian Innovation Fund (HIF) defines humanitarian innovation both in terms of its foreseen outcome (‘a creative solution, or novel idea, which helps address a problem or seize an opportunity’) as well as a process (‘an iterative process that identifies, adjusts, and diffuses ideas for improving humanitarian action’) (Warner, 2017, 6-7). ALNAP defines humanitarian innovation as an iterative process that identifies, adjusts and diffuses ideas for improving humanitarian action (Obrecht et al., (2017). Bloom and Betts define it as ‘a way of potentially transforming humanitarian practice’ (2013, 3). Similarly, Betts and Bloom (2014) define it as a process for adaptation and improvement, which includes locating and scaling humanitarian solutions to problems in the form of products, processes, and wider business models.

Type of Definition	Frequency
Type of Definition	
Outcome-based	34
Process-based	17
System-based	4
Type of Innovation	
Products	19
Processes	18
Position	7
Paradigm	8
Business Models	1

Table 3. Definitions of Humanitarian Innovation.

Innovation in the context of humanitarian aid is framed overwhelmingly as outcome-based. The manner in which innovation is conceptualised in the humanitarian sector does typically not go into detail on the process of innovation, i.e. how innovation is created. Increasingly, the process has been considered more from a system's perspective (Ramalingam et al., 2015). The role of multiple actors in the innovation processes and their relationships and interactions has come into view, leading to the idea of a system of innovation. 'An innovation ecosystem is the evolving set of actors, activities, and artefacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors' (Granstrand & Holgersson, 2020, 3). Characteristic of this system view is the emphasis on the notion of innovation not being a single-actor effort, but rather as a dynamic and emergent process that is the product of multiple actors and their relationships. This conception, however, is still rare in the literature. Instead, the most widely adopted definition of innovation is provided by Bessant and Tidd, who define it as dynamic processes which focus on the creation and implementation of new or improved products and services, processes, positions and paradigms (2007). These '4Ps' organise innovations into four types, depending on where the proposed improvement or change is occurring. They can be summarised as follows:

- Product – changes in the things (products/services) an organisation offers;
- Process – changes in the ways these offerings are created and delivered;
- Position – changes in the way services are presented to the user and how these are communicated and reframed by government and other actors;

- Paradigm – changes in the underlying mental models that shape what the organisation does.

The value added by each of the 4Ps in humanitarian settings, ‘implies improvements in efficiency, effectiveness, quality, or social outcomes/impacts.’ (HIF, 2018, 1). Some articles discuss innovations that include multiple categories of the 4P model at the same time. For example, 3D printing (Tatham et al., 2015), which is a new manufacturing process, can also lead to a paradigm shift in the thinking about humanitarian supply chains concerning their supply chain configuration, the choice of suppliers, and the delivery mechanism. Despite blurry boundaries, the 4Ps model has become the principal reference point for what innovation is, according to Sandvik (2017).

Sandvik (2017) states that the 4Ps are accepted as true without reference to facts or proof. Indeed, critics have suggested that this engenders an analytical slipperiness, noting that ‘the difficulty of picking apart the stakes of humanitarian innovation is largely a result of the scale of the “4Ps”’. (Scott-Smith, 2016). Despite their tremendous scope, the 4Ps are being continuously amended, with additions such as policy innovation or business model innovation coming into the mix. As Finnigan and Farkas state, ‘the promotion of the application of the 4Ps in the humanitarian sector failed to emphasise that the 4Ps act as one part of an overall business strategy. Without the strategy that articulates the intent, business structure, and plan, the 4Ps simply become another process activity to perform’ (2019, 6). So, even the most used definition of innovation in the sector is fiercely debated, and no consensus thus far has been reached. Also, in practice very few innovations appear to initiate a paradigm shift. For instance, most of the grants of Elhra’s HIF have been for product and process innovations, rather than position and paradigm innovations (Lawday, Poulson & Foley, 2017). Currion (2019) states: ‘Though new goods, methods and organisational forms can be seen in the humanitarian industry (particularly those enabled by networked technologies), very few seem to be able to gain significant traction’ (Currion, 2019). Paradigm innovation is extremely hard to come by and extremely hard to see: ‘It is an open question whether it is even possible to intentionally design paradigm innovations’ (Currion, 2019).

5.2. Definition of “Successful Innovation”

Despite growing investments in humanitarian innovation, very little attention is given to defining the concept of “successful innovations”. Research conducted by Obrecht and Warner (2016), which is commonly referenced in the literature, conceptualises success as either impact (improved solution or generating learning) or adoption (innovation diffused successfully). The success of an innovation is thus judged according to three success criteria:

- Adoption: The innovation is taken to scale and used by others to improve humanitarian performance;
- Improved Solution: The innovation offers a measurable, comparative improvement in effectiveness, quality or efficiency over current approaches to the problem addressed by the innovation;
- Consolidated Learning and Evidence: New knowledge generated or the evidence base enhanced around the area the innovation is intended to address or performance of the innovation itself.

The “improved solution” criterion, raises the question: an improvement for whom? Problems and solutions in the humanitarian sector are multifaceted; what is a “solution” for a donor or agency may not straightforwardly be considered a solution for field staff or affected people.

Consequently, a “failed” innovation is one that is not widely adopted and achieves no impact (neither an improved solution nor consolidated learning). Notably, the humanitarian innovation literature distinguishes between “good fail” and “bad fail”. An innovation may fail to diffuse, but as long as consolidated learning and evidence is obtained (e.g. to use in future innovation endeavours), it is considered a “good fail”.

Obrecht and Warner (2016) additionally mention the following additional success criteria for humanitarian innovation:

- Involvement and respect of affected people: Be it directly or indirectly, demonstrating how their rights and interests are respected in an innovation process;
- Efficient development: Resources must be used efficiently in the development of innovation;
- Unique Impact: When the humanitarian system largely ignores a particular issue, such as (formerly) cash-based assistance or menstrual hygiene, innovations that address such novel areas can have a high degree of risk, but also a unique impact on the system around them.

These factors can be seen as complementary to the above-mentioned ones. However, it is notable that their inclusion already creates overlap with the success criteria defined above. For instance, an improved solution may entail a unique impact but inefficient development, so to what degree it would be a success or not remains questionable.

Even this broad conceptualisation of success is not uniformly employed in the literature. Instead, we see in the literature that an innovation’s success is typically evaluated on a case-by-case basis. In most cases, some key performance indicators are chosen, and depending on the score or points achieved, the innovation is deemed a success. For example, a medical training given to refugees in a refugee camp was deemed a success based on the

number of students enrolling in the course and the score obtained on the final exam (Lovey et al., 2021). These criteria for success are on the output and outcome level, but do not evaluate impact of the intervention, which would need to be evaluated by measuring the effect on health outcomes after the course was completed. Further, if impact is indeed measured, the ultimate effects are often not taken into consideration, because measurement and evaluation of key performance indicators are not conducted on a long-term basis, due to a lack of funding. The sparsity of evidence, particularly regarding the 'impact' dimension, is also frequently noted in the literature.

There have, however, been efforts to evaluate innovations on the portfolio level. Portfolio-wide evaluations may aid in conceptualising success more comparatively and to judge innovations according to consistent criteria. However, the portfolio evaluations are still mostly being done based on case studies. For instance, the portfolio of Innovation Norway utilises self-evaluation using a pre-conceived framework to judge the success of a select few case studies (Hill, 2018). Similarly, the UK's Humanitarian Innovation and Evidence Programme states that for its evaluation case studies are being used to test and refine the HIEP theory of change and to provide an in-depth understanding of how best to support evidence generation and use in specific humanitarian contexts (Itad, 2014). The use of case studies to evaluate an overall holistic innovation approach may prove disadvantageous, as survivorship bias and selection bias could lead to the chosen cases and their success drivers may not be representative. On the other hand, Elrha's portfolio evaluation analysed its innovation portfolio in its entirety, with pre-conceived success criteria related to outcomes, effectiveness, internal factors, funding, and relevance of the innovation (Lawday et al., 2017).

In the studied literature, we note that most sources make explicit reference to a specific innovation, framing it in a positive light, i.e., as successful, even when not explicitly calling it a success, despite the absence of any scientific evaluation of the innovation's impact. We do urge caution in taking these assessments literally, as the manner in how success is evaluated are typically self-assessments by the implementers. This once more showcases the need for more rigorous processes for obtaining evidence (ALNAP, 2018).

6. Practical Findings

In this section, we discuss findings with individual innovations as the unit of analysis, in order to gauge common attributes of innovations that have been introduced into the humanitarian sector, with respect to several characteristics:

- The sectors into which innovations are introduced in the humanitarian context
- The types of innovations most frequently described in the literature
- The special role that is played by technological innovations
- The targeted end-users of the innovations

6.1 Innovation Sectors

Sector	Frequency. ntioned	%
Coordination & Support Services	33	10.31%
Health	24	7.50%
Water, Sanitation and Hygiene (WASH)	19	5.94%
Emergency Telecommunications	18	5.63%
Logistics	18	5.63%
Education	15	4.69%
Food Security	13	4.06%
Protection	11	3.44%
Early Recovery	7	2.19%
Camp Management & Coordination	4	1.25%
Shelter/NFI	4	1.25%
Child Protection	3	0.94%
Mine Action	3	0.94%
Nutrition	3	0.94%
Multi-sectoral possibility	82	25.63%
Sector Not Specified/NA/No further mention	63	19.69%
Total	320	100.00%

Table 4: Sectors and Clusters of Humanitarian Innovation Activity

The results highlight that Coordination & Support Services is the leading sector into which humanitarian innovations are introduced. These innovations are generally implemented in agencies and include the adoption of project management information systems and related digital data-gathering technologies, which has moved many humanitarian organisations over the past decade away from inefficient spreadsheets and paper-based systems. Secondly, innovations within the Health sector are prominently featured. Other notable

clusters include Logistics, WASH, and Food Security. In addition to innovations being directed at specific clusters, we also noted innovations with either Multi-sectoral possibility, meaning an innovation could be used in multiple sectors, for instance, drones being used both in logistics (transporting cargo) and early recovery (imaging). Further, some innovations were not directed at any specific sector.

6.2. Innovation Types

As pointed out in the previous section, the literature refers to different innovation types, along the lines of the 4Ps. Additionally, we identify business model and policy innovations as frequently occurring in the literature. This section describes which type of innovation occurs most frequently in the literature.

Type of Innovation	Frequency	Percentage
Product innovation	156	54.55%
Process innovation	148	51.75%
Position innovation	34	11.89%
Paradigm innovation	38	13.29%
Business Model innovation	41	14.00%
Policy innovation	39	13.64%
Multiple	96	33.57%

Table 5: Types of Innovation in Literature

- **Product / Service** innovation refers to a change in what is offered. Product or service innovations are described most frequently (156). Examples of a product innovation include the development of affordable wheelchairs for use in emergency response contexts (ALNAP, 2015), the development of portable media centres which provide educational resources and tools to refugees and displaced persons in camps in different camp settings (Iqbal, 2017), or ready-to-use therapeutic foods for children with uncomplicated severe acute malnutrition (Kangas et al., 2019);
- **Process** innovation aims to change how a product/service is created or delivered. Within the literature, we found 148 instances of process innovations. Examples include the use of user-centric design to deliver sanitation services in emergencies by projects funded by Elrha's Humanitarian Innovation Fund (Bourne, 2019) or human-centred design approaches by DEPP Labs with the aim of developing more responsive and locally-led humanitarian and preparedness programming (Konda et al., 2019);
- **Position** innovation seeks to change the way in which a product or service is targeted and delivered. Amongst the 34 position innovations mentioned,

examples included changes in the location of handwashing materials and facilities to promote and enhance child handwashing (Watson et al., 2020). This category of innovations mostly focuses on targeting previously non-accessible or marginalised communities;

- **Paradigm** innovation relates to a change in the underlying mental models that govern our approach. The relatively large amount (38) of innovations pertaining to this category relates to the focus on driving localisation through humanitarian innovation (Tatham et al., 2017), the introduction of innovative financing mechanisms (Spiegel et al., 2020) or the role of cash-based programming in replacing traditional forms of aid delivery (Heaslip et al., 2018);
- **Business Model** innovation relates to the situation in which a reframing of the current product/service, process and market context results in seeing new challenges and opportunities and letting go of others. Examples include the introduction of joint ventures or social enterprises (Vieille, 2020), or innovative business strategies to bring humanitarian innovations to scale (Gray et. al., 2019).
- **Policy** innovation refers to an innovation that relates to a policy or policy process. The Australian government's priorities on Gender Equality and Women's Empowerment are an illustration of policy innovation. Through these priorities, the government aims to address gender issues, ensuring that women can make their voices heard amidst crisis (Australian Aid, 2016);

The majority of humanitarian innovations mentioned across literature constitute either product or process innovation, which tend as a whole to offer more incremental change compared to 'position' and 'paradigm' innovations (Lawday et al., 2017). It is, however, important to note that the different types of innovation have fuzzy boundaries, nor are they exclusive. There can be considerable overlap as to which factors could be considered innovative (Francis & Bessant, 2005). Innovations frequently take on multiple characteristics and can evolve over time. This was also clearly demonstrated by the various innovations which pertain to multiple types (96). For example, the mobile Vulnerability Analysis Mapping project of World Food Programme uses mobile technologies to collect food security information remotely (Robinson & Obrecht, 2016a; Morrow et al., 2016). It brings together a wide range of tools to support practitioners in data collection (product innovation) which simultaneously change the ways in which data collection takes place by (process innovation) as well as brings along considerable shifts in the fundamental approach to humanitarian work by facilitating remote operations (paradigm innovation).

6.3. Technological Innovations

According to UNOCHA (2017b), the humanitarian sector has experienced more disruption due to technology in the past decade than in the past 50 years. Notable studies view technology as the prime enabler behind improved effectiveness and efficiency within the sector, focusing on mobile applications or the role of UAVs, 3D printing, and other cutting-edge technologies. Technological development, whether designed specifically for humanitarian contexts or adapted from other use cases, is seen as a fundamental contextual driver of humanitarian action and which types of innovations are ultimately implemented. From the literature we reviewed, roughly 80% of all product innovations were technological in nature. This translates to making up close to 50% of all innovations analysed. Table 4 displays the most frequently appearing technological innovations. Percentages are given with respect to all innovations identified in the corpus.

The technological innovations found in the corpus are ambitiously designed to simultaneously meet multiple objectives such as increasing reach, efficiency and effectiveness. From the literature surveyed in this review, the three most frequently occurring types of technological innovations are crisis maps, mobile applications, and (UAVs).

Digital Technology Innovations	Frequency	Percentage
Mobile Applications	48	12%
Crisis Maps & Dashboards (incl. GIS)	30	8%
Unmanned Aerial Vehicles (drones)		7%
	29	
Digital Cash Transfer	28	7%
Internet Access & Connectivity	24	6%
Blockchain (Distributed Ledger Technology)	18	5%
3D printing	17	4%
Biometrics & Digital Identity	17	4%
Toolset	8	2%
Internet of Things	6	2%
Digital Communication	5	1%
Industry 4.0	4	1%
Artificial Intelligence	4	1%

Virtual Reality	3	1%
Others	160	40%
Total	398	100%

Table 6. Frequently Occurring Digital Innovations.

However, over recent years also critical literature has emerged on these “humanitarian technologies”, questioning the humanitarian sector’s “neophilia” and to which extent excessive tech-optimism clouds the judgement on whether an innovation is genuinely game-changing or whether it merely “fiddles around the edges” (Scott-Smith, 2016). The risk is, that due to tech fervour these solutions might take the place at the expense of more routine and less “flashy” activities, which would, however, have a larger impact on affected populations (Scott-Smith, 2016).

6.4. The Innovation Target

Use of Innovation	Freq. Mentioned	% per Innovation
Use of Innovation by affected communities	76	23.75%
Use by practitioners to direct benefit of communities (i.e. at field level)	69	21.56%
Use by practitioners/donors (i.e. at headquarter level)	99	30.94%
Concept/Strategy Only (no direct mention of end-users)	76	23.75%
Total	320	100.00%

Table 7: End-Users Targeted by Humanitarian Innovation

Humanitarian innovation can broadly be divided into two categories, depending on whom the innovation is targeting: Innovation that is directed at affected populations as end-users and innovation that focuses on practitioners as end- users. During the literature review four more distinct subcategories emerged

- The first direction sees innovation that aims at the affected population to be the end-user, giving a certain amount of ownership to them. This includes examples such as solar-powered saltwater pumps (Prasanna, 2021) or soap with toys inside for this end-user emerging in the WASH sector (Watson et al., 2019);
- The second direction aims for practitioners in the field to be end-users, bringing indirect benefit to the affected communities. Examples of this type of innovation includes web-based disease outbreak detection and response in emergency settings (Karo et al., 2018) or infrastructure innovation such as blockchain technology (Ko & Verity, 2016; Zwitter & Boisse-Despiaux, 2018);

- The third category sees innovation in which donors and practitioners working at headquarters are the end-user of the innovation. They have a lesser amount of product innovation among them, instead focussing on process innovation. This category includes multi-year financing (Sida et al., 2019) or novel data-sharing practices such as the Humanitarian Data Exchange platform by the OCHA Centre for Humanitarian Data, which allows for the sharing of data between donors and practitioners in order to increase the amount of information available and share best practices for more efficient and informed decision-making (de Winter et al., 2019);
- The last category does not mention specific innovations and instead introduces new concepts, policies, or paradigms to the field of humanitarian innovation.

Of the 244 innovations that specifically mention targeting specific end-users, 168 (68.85%) are innovations targeting practitioners, either in the field or at headquarter level, while only 23.75% of innovations are to be used directly by affected communities.

6.5. Innovation Management Strategies

Innovation management strategies in the sector are primarily related to the process of creating innovation, managing innovation, and which facets must be specifically considered in the strategies (e.g. diffusion and scaling, design, ethical considerations). In line with Obrecht et al. (2017), we determine four engagement strategies for humanitarian innovation.

1. **Project-level strategy** refers to actors focussing on the implementation of a single project, product, or process. This type of management judges each innovation based on its own merits and shortcomings, without necessarily looking at trade-offs and synergies with other innovations or projects.
2. **Programme-level strategy** relates to programmes or organisational units encompassing several innovation processes, often pursued by. Such strategies are often pursued by 'hubs' or 'units' within organisations that work across different sectors or programme areas, overseeing or supporting multiple distinct innovation processes (e.g. UNHCR Innovation Unit, World Food Programme (WFP) Cooperating Partners Innovation Fund, Oxford's Humanitarian Innovation Project, etc.)
3. **Portfolio-level strategy** looks at multiple separate innovation projects and programmes. This enables funding of projects with a range of risk levels and assess them at a collective rather than an individual level (Obrecht et al., 2017; Obrecht & Warner, 2016). The positive impact from one or two big, transformational successes in a portfolio can thus suffice to justify the opportunity cost of many failures (Kasper & Marcoux, 2014). Such portfolio-approaches are oftentimes carried out by independent actors (e.g. Humanitarian Innovation Fund, Global Innovation Fund).
4. **Systems-level strategy** approaches innovation holistically and is concerned with how each part of an innovation process – knowledge transfer,

development, adjustment, and diffusion – is affected by the involved actors, their relationships, and other systems. For example, the Center for Research in Innovation Management research on evaluating different systems for innovation would be an example of a system-level scope for assessing and understanding innovation practice (Ramalingam et al., 2015).

How to best manage innovation in humanitarian contexts has received considerable attention through the sharing of lessons learned and best practices in terms of innovation management as is evidenced by the creation and publication of increasing amounts of resources and toolkits, such as the Humanitarian Innovation Guide or the UN Innovation Toolkit. Best practices and lessons learned focus on different topics, such as human-centred design (Bourne, 2019; Konda et al., 2019), participation and inclusion of local populations in innovation processes (Robinson & Obrecht, 2016b), collaboration with different actors such as researchers or the private sector, ethical considerations in designing and conducting innovation in humanitarian contexts (Sandvik, 2019), the role of evidence in guiding innovation processes and its role in driving adoption (Dodgson & Crowley, 2021), or suggestions on how to overcome challenges to scaling humanitarian innovation (Elrha, 2018b).

Although the different level strategies are acknowledged, most of the literature describes humanitarian innovation strategies from a project-level perspective. Programme and portfolio-level analyses are rare and system-level reflections have only recently started to draw attention. This limits the opportunities to study humanitarian innovations from a comparative- or systems-level perspective and hence to develop a more holistic understanding for how innovation should be managed.

7. Thematic Findings – Factors Impacting the Performance of Humanitarian Innovation

In the literature, we identify multiple recurring thematic areas surrounding the concept of humanitarian innovation. These are typically portrayed as factors that either enable innovation's potential for humanitarian action (drivers) or hinder it (obstacles). While other themes were mentioned, we describe only themes with at least ten mentions throughout the literature we surveyed. Hence, in this section, we outline the nine most frequently appearing themes, ordered by frequency of appearance. Figure 6 displays the frequency of the nine most commonly appearing themes.

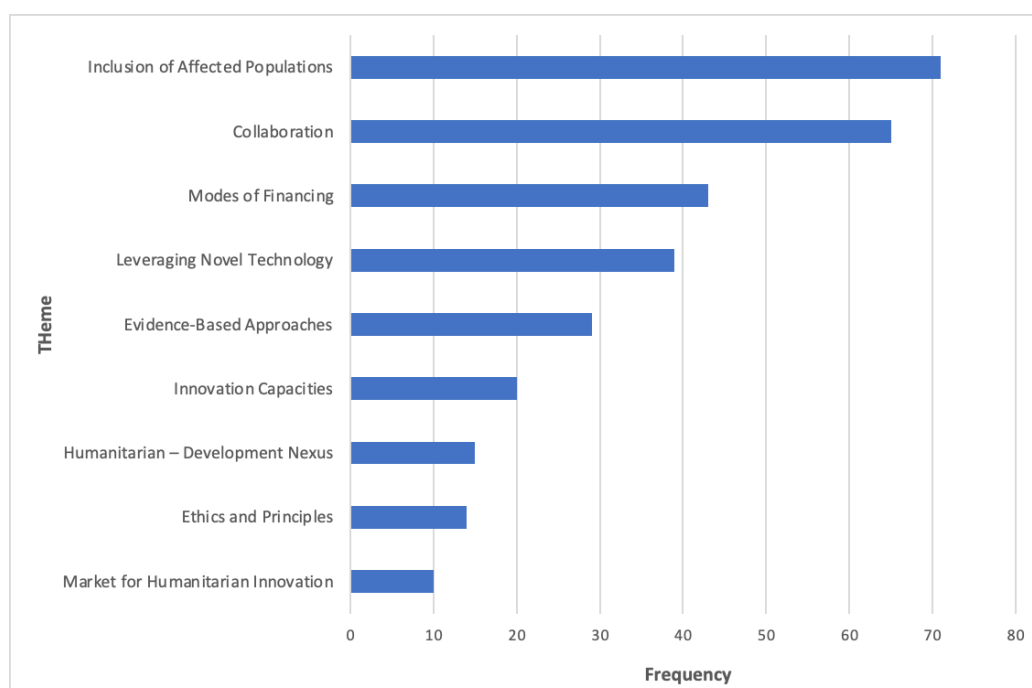


Figure 6: Frequency of Prevalent Themes Identified in the Literature

In Table 8, we briefly describe each theme, as well as how the literature portrays them as drivers or obstacles to humanitarian innovation

No.	Theme	Description	Frequency	Driver	Obstacle
1	Inclusion of Affected Populations	Inclusion of affected populations into the innovation process	71	Ensuring active participation and inclusion of affected populations in innovation agendas and processes.	Top-down innovation driven by donors in the Global North
2	Collaboration	Collaboration amongst donors and practitioners, with the private sector, and with intermediaries	65	Collaboration and alignment between donors, innovators, humanitarian organisations, and private sector actors.	Disregarding complementary sets of expertise, working in silos, not using synergy potential

3	Modes of Financing	The modes of financing humanitarian innovation	43	Increase the quality and quantity of funding going to innovation actors, and steer funding towards innovations explicitly catering to the needs of affected populations.	Unilateral or bilateral financing, short time horizons
4	Leveraging Novel Technology	Leveraging technological development in humanitarian contexts	39	Utilising cutting-edge innovation when it is most suited for the respective contexts	Technophilia, over-reliance on gadgets
5	Evidence-Based Approaches	Basing funding decisions and agenda-setting on a robust evidence base	29	Facilitate evidence-based approaches and data-driven decision-making, for facilitating the operationalisation of appropriate innovations	Lack of Evidence and Data in decision-making
6	Innovation Capacities	The role of innovation capacities and capabilities within donor and practitioner organisations	20	Providing a conducive environment for innovation inside donor organisations through fostering innovative cultures and strengthening innovation competencies	Lack of Institutional Support and a culture not embracing innovation
7	Humanitarian	Stronger linkage	15	Link innovation	Silo-thinking

	– Development Nexus	between humanitarian and development efforts		with the humanitarian— development nexus	between humanitarian and development practioners
8	Ethics and Principles	The potential conflictbetween commonplace innovation mantras (e.g. fail fast) and key humanitarian principles (do no harm)	14	Innovating without sacrificing humanitarian principles	Innovating while disregarding ethical principles
9	The Market for Humanitarian Innovation	The market structureof the humanitarian sector, where donors, rather than affected populations,are the ones paying for innovations	10	Taking into account the affected populations’ needs when financing innovation	Donors financing innovations based on own preferences only

Table 8: Explanation of Prevalent Themes Identified in the Literature

7.1. Inclusion of the Affected Population

The collaboration with beneficiaries, meaning the affected populations, is considered the single most important ingredient for successful innovation, with many authors concurring that collaboration with beneficiaries and the community is an effective way to find suitable innovations to the context and the setting (Krishnan, 2020; Turk, 2020; Dodson & Bargach, 2015; Sandvik, 2017). Community involvement can also benefit the implementers. The benefits include input on innovation creation, feedback on the innovation operation, and innovation promotion in the field for the innovators. For the local population, the benefits include the engagement of locals in new projects, local training, talent development, and the creation of practical solutions (Obrecht & Warner, 2016; Bertone et al., 2018; Heaslip et al., 2018). The literature also revealed a need to enable the active engagement of groups who may be socially marginalised, such as women, girls, and refugees. By triggering these groups' participation, it becomes easier to identify problems, design solutions, and implement feedback (Schmitt et al., 2021; Oxfam & WEDC, 2018; Bessant et al., 2015; Sida et al., 2019). Increasingly, donors and practitioners provide platforms at different levels that are explicitly supporting and committing to

initiatives around humanitarian innovation from affected communities through co-creation and bottom-up innovation (Betts et al., 2015; Scott-Smith, 2016).

However, the literature laments the underdeveloped inclusion of the local population, i.e. those people actually affected by a humanitarian crisis. The affected population does not get adequately involved in any stage of the innovation process- from design to production to giving feedback, with Elrha (2017b) suggesting that only 33% of humanitarian innovators consult with affected populations during their innovation processes. This is symptomatic of the lack of targeting of innovations at affected populations, as shown in the previous section. As a result, the design of the products and services that are sponsored by far-away donors are inappropriate for the context (Humanitarian Grand Challenge, 2020). When the conditions are not well known or rapidly changing, better outcomes result when those affected are in control of, or at least involved in, the innovation processes (Bahadur & Doczi, 2016; Honig, 2019).

The need to recognise the specific culture, context and social norms of the humanitarian setting is stressed by humanitarian practitioners and donors alike (European Parliament, 2019). Nevertheless, there is a lack of humanitarian funding available to support such initiatives. Oftentimes, funding that is channelled to “local” partners tends to go through NGOs that may have little representative relationship to crisis-affected communities. Funding requirements and accounting and auditing standards need to be adjusted to enable affected communities to access seed funding and encourage innovation by and for crisis-affected populations (Betts et al., 2015). IASC (2020) advocates for a wide form of local engagement, by recognising and supporting the role of mayors, village elders, faith leaders, camp or community leaders in the innovation process.

7.2. Collaboration between (other) Innovation Actors

A primary theme that is present in the literature is collaboration. Collaboration between various types of stakeholders (donors, practitioners, private sector) is considered a primary driver for fostering more effective, efficient, and appropriate innovation in the humanitarian sector.

Practitioners

A primary driver for fostering more effective, efficient, and appropriate innovation in the humanitarian sector is collaboration between multiple stakeholders. This refers to increased cooperation amongst donors, for the purpose of agenda setting, amongst practitioners for the sharing of expertise, the inclusion of the affected populations in the innovation process, and the inclusion of private sector actors.

The humanitarian sector is considered to have ‘a culture of isolation that creates barriers’ (Betts & Bloom, 2014), which infringes on the collaboration between multiple stakeholders. In the literature, increased integration of practitioners' operations is recognised as essential for supporting innovation in the humanitarian sector and can indeed be considered an innovation itself (Betts & Bloom, 2014). Several initiatives have been started towards achieving this goal, such as the Grand Bargain or the Global Alliance of Humanitarian Innovation. These and other initiatives promote pooling and combining data, analysis, and information; improved joined-up planning and programming processes; effective leadership for collective outcomes; and pursuing financing modalities to support collective outcomes (World Bank, 2018).

Donors

Collaboration between donors is typically portrayed on two levels. First, through the bundling of resources. Several initiatives have been started towards achieving this goal, such as the “Grand Bargain” or the “Commitment to Action”. Such initiatives promote pooling and combining data, analysis, and information; improved joined-up planning and programming processes; effective leadership for collective outcomes; and pursuing financing modalities to support collective outcomes (World Bank, 2018). Collaboration also serves as a coordination and accountability mechanism, where donors report on the progress they have made in regards to accomplishing their humanitarian innovation objectives. The collaboration between donors for the purpose of agenda-setting, sharing of best practices and data, therefore can stimulate and encourage innovation.

The second level of collaboration is on the project-level. Multiple actors exist in the humanitarian innovation space, the capacities and capabilities of which all differ. Partnerships within specific innovation projects can bring new capabilities into the development of a solution, such as creative expertise, technological expertise, access to users, access to funds or a licence to operate. Taking full advantage of the capacities in the system requires incentives to encourage interaction, collaboration and partnership. Creating such synergy effects can be facilitated by donors through innovation consortia and multi-stakeholder projects.

Private Sector

Besides collaboration amongst donors, partnerships with the private sector are also described as key requirements to facilitate humanitarian innovation in the literature (Council of the European Union, 2017). Over the past decade, faced with growing resource constraints, humanitarian agencies have held high hopes for contributions from the private sector. Initially seen simply as an alternative source of funding, since about 2010, the private sector has been acknowledged as playing other roles, most notably in product and process

innovation. It has also been increasingly recognised as operating at various scales, from multinational corporations to national companies to small businesses created by refugees and internally displaced persons. Further, collaboration with the private sector, often in public-private partnerships (PPP), has become increasingly common. Collaborative private sector-NGO partnerships allow both organisations to combine their expertise and create contextual, innovative solutions for humanitarian and community-based response, something more essential than ever as new types of crises emerge globally. Donors, for their part, appreciate private sector involvement because it means lower overhead and less need for constant engagement and monitoring (Sandvik, 2017), as well as the opportunity of leveraging private sector innovation expertise.

However, private sector actors' involvement in the humanitarian space is also seen as entailing potential downsides and risks. The silicon-valley style approach of innovating and "failing fast" can violate the "do no harm" principle and ultimately negatively affect the beneficiaries, who are most likely to bear the costs of the failure (Sandvik et al., 2017). Hence, there remains significant hesitance about whether businesses that seek profit can uphold humanitarian principles (Betts & Bloom, 2014). Also, due to the perceived intention of private sector actors prioritising shareholder value maximisation, there is concern that the affected populations' needs will be neglected. The notion that aid money might be used to pay a return to investors is also sometimes seen as unethical. The increase in private sector activity has furthermore led to a debate on ethics and technical standards, responsible innovation, particularly regarding datafication of vulnerable populations (European Parliament, 2019).

Hence, there exists a degree of concern about the practicality and underlying ideological issues associated with working with external partners, particularly from the private sector. The strong values (and ethics) underpinning the sector may be acting to constrain innovation and to limit the potential for resource sharing and amplification.

Intermediaries

Another mode of fostering cooperation described in the literature is through intermediaries. Intermediaries are brokers facilitating the open exchange of new information, knowledge and technological invention between 'seekers' and 'solvers'. In response to identified gaps in the ability of international humanitarian action to innovate, such as lack of dedicated resources and spending and constraints in innovation management capacity, a number of intermediaries such as Elrha's Humanitarian Innovation Fund or the Global Innovation Fund has appeared in the humanitarian sector. Lawday et al. similarly state that their purpose is to 'support organisations and individuals to identify, nurture and share innovative and scalable solutions to the

challenges facing effective humanitarian assistance' (2017, 1). The reasoning behind these intermediaries funding innovation projects is to leverage their expertise in innovative products and practices and thereby increase the quality of innovations sponsored. These types of funds largely follow a model of seed-funding, where they provide startup capital for piloting new solutions. Despite the acknowledged necessity for collaboration, however, there exist frequent challenges to collaborate due to the complex array of actors involved in the humanitarian innovation context (House, 2020; Fekete et al., 2021).

7.3. Modes of Financing

Adequate funding is one of the primary enablers of humanitarian innovation. The necessity of improving the effectiveness of the finances contributed by donors is a frequently recurring theme in the literature. However, even though there has been an increase of absolute funds for innovation in the last years, many authors state that the lack of financial resources is still an obstacle to humanitarian innovation (Watson et al., 2020; Caniato et al., 2017; Sandvik et al., 2017; Nelis et al., 2020; Lovey et al., 2021). Indeed, the funding gap between funds available and funds needed is continuing to grow, as is true for the entire humanitarian aid sector.

The financial resources that are available for humanitarian innovation are not specifically well-designed for supporting the whole innovation process. Early stages of the innovation process usually receive more funding, whereas there is little financing for the adoption and diffusion stages, where programmes often stall (Rush & Marshall, 2015; Sandvik, 2017; European Parliament, 2019). Therefore, innovations often get stuck at the pilot phase (Sahebi et al., 2020; Elrha, 2018b; Ko & Verity, 2016; Obrecht & Warner, 2016). "Challenge funding" contributes to this "pilot and crash" phenomenon, by which new programmes keep being introduced but then cannot find long-term financial support (Benton & Glennie, 2016). This insufficient support to "follow-through" is also seen in the recovery phase and durable solutions phase, mainly due to donor fatigue and lack of resources (Fladvad Nielsen et al., 2016). Implementable and durable humanitarian innovations are said to be achievable only if sufficient financial support of stakeholders is provided (Scott-Smith, 2016; Scott & Mars, 2015; Heilbrunn & Iannone, 2020), for instance from donors but also from host countries and countries nearby (Redvers, 2017; Betts et al., 2015; Zwitter & Herman, 2018). Stakeholders' support both financial and political must be maintained through the whole innovation process, especially in the last stages of implementation and scaling up/diffusion, where evidence collection and impact evaluations are carried out (Rush & Marshall, 2015). Follow-up funding and incubation support can also help the most promising innovations reach scale (Benton & Glennie, 2016).

New funding methods are being employed by donors to make the funds available more effective. Pooled funds collectively channel more funding (both

in volume and percentage terms) to local and national actors than bilateral donors, particularly in conflict contexts (Metcalf-Hough et al., 2021). Also, donors may achieve better results by donating in the form of multi-annual contributions to humanitarian agencies. (IOB, 2015) Shifting from annual to multi- year humanitarian funding can also aid by giving innovators access to more reliable, long-term funding streams. Such longer-term funding is called for by innovators, to increase reliability and predictability of contributions. This allows recipients to use this funding strategically across their respective mandates to ensure maximum impact with donor funds, scale up sustainable solutions, invest in innovative approaches and adapt to changing situations in emergencies. However, while multi-year financing is extremely popular with recipient practitioners, clear causal effects on improved added value to the affected population is not clearly causally established (Sida et al., 2019).

Additionally, Research by the Humanitarian Innovation Fund states that strict funding deadlines could stifle an innovation process, whereas more flexible approaches to funding sources supported a successful innovation (Betts et al., 2015). This is an unsurprising finding, nevertheless, grantees cite flexibility by donors as rare. Therefore, donor flexibility is often stressed as a key factor for innovation. Obrecht and Warner (2016), for example explicitly state that their project succeeded only because the donor gave a no-cost extension on a deadline. Yet flexible funding poses certain risks to donors: in some cases, delays on a timeline are necessary to get a prototype right; in other cases, these delays can be the result of mismanagement and poor planning.

7.4. Technology-Driven Innovation

Technological innovations are frequently framed as being “game-changers” in the literature. Humanitarian innovators tend to overstate an innovation’s potential, often claiming that technological objects can revolutionise the delivery of assistance (Pilloton, 2009; Shall, 2009; Johnson, 2011). According to Sandvik et al. (2017), a game changer is a new constituent that notably alters an existing situation or activity: ‘A game changing technology holds the promise of changing not only how things are done and by whom, but what is possible within (or despite) a given context.’ Eisenstein (2015) and Soll (2014) declare that such innovations only give a competitive advantage within the existing rules, which are formed over a long time and are most rarely toppled by a single invention. In the literature, technology is portrayed both as a driver and obstacle (Gaffey et al., 2020; Pascucci, 2019; Zwitter & Herman, 2018; Dandurand et al., 2020). The technological imperative is the idea that new technologies are essential and, hence, they must be developed and introduced in every context needed (Scott & Mars, 2015).

The penetration rate of technology is also found to be an important factor for innovation. In a regional consultation report from the World Humanitarian Summit (2016) it is argued that the higher the penetration rate of technology,

the higher the opportunity to innovate. Stakeholders recognise the potential that technological innovation has in humanitarian assistance, especially supporting the phases of prevention and preparedness of integrated disaster risk management (European Parliament, 2019). There are different benefits and opportunities for humanitarian aid beneficiaries regarding technological and digital capabilities that authors have identified. There are educational and training improvements, as technology can be used, for instance, to face challenges related to multilingual classrooms (Benton & Glennie, 2016). Mobile technology and internet penetration also bring opportunities for humanitarian innovation (Bolon et al., 2020). For example, mobile learning can be useful to displaced populations (Menashy & Zakharia, 2020). Moreover, technological innovations are driven by needs, issues or challenges surrounding the humanitarian context. Raftree (2020) calls for a digital transformation as users can be hesitant to engage with services that are useful for them mainly due to issues regarding data security. Seifert et al. (2018) argue that due to the lack of available data and forecast accuracy in disaster-affected areas more efforts should be put into increasing the contributions of information and computer technologies (ICTs).

Technology can spread beyond the affected populations and benefit the humanitarian sector as a whole. For instance, digital infrastructure like the blockchain, which was originally developed as a mechanism used for financial transactions, is now used as a tool to improve the complex supply chain of the humanitarian sector (Rejeb & Rejeb, 2020). Similarly, drones and satellites are cited as examples that ease the retention of imagery in areas that are difficult to access otherwise (Quinn et al., 2018).

Regarding the limitations or challenges of technological innovations in the humanitarian sector, some literature argues that there is an “overblown tech optimism” (Menashy & Zakharia, 2020) that makes innovators to narrowly focus on technological solutions instead of other approaches, leading to missed opportunities (Smith et al., 2020). The humanitarian neophilia concept relates to such overuse of technology. According to Scott-Smith (2016), the problem is: ‘They pursue gadgets at the expense of routine activities. They risk reducing complex humanitarian problems, which need political engagement and have a significant social angle, to the provision of material goods. At their worst they combine an excess of enthusiasm with a shortage of understanding’. According to Scott-Smith (2016), the tendency to ‘overstate the object’ is a recurrent characteristic of the humanitarian innovation movement. Such a scale of vision is characteristic of ‘humanitarian neophilia, which prioritises novelty over suitability and applies this novelty on a severely restricted horizon’. Additionally, when humanitarian actors incorporate such over-stated technologies into their work they may also incorporate unethical values embedded in them (Sandvik, 2015).

Furthermore, the processing of some types of data such as big data stemming from social media or biometric devices or satellite imagery, which often relies on machine learning algorithms, is oftentimes not yet reliable without human quality control. A more uniform data quality and standardisation must be reached, processing made reliable, and only then can more data-driven services be provided by donors reliably (de Winter et al., 2019). The emphasis on using data responsibly also occurs frequently, while also the need for extensive training of human resources for new data-driven methodologies is pointed out (Turk, 2020; de Winter et al., 2019).

Further problems may be caused by the infrastructural requirements for technologies, which in crisis contexts are often not given for adequately operating high-tech equipment (European Parliament, 2019). Further, overly relying on technology may widen the so-called digital divide between those affected people who have access to technologies, thereby reaping their benefits, and those who cannot access them, who come away empty-handed (Raftree, 2020; UNOCHA, 2021).

7.5. Evidence-Based Approaches

In the literature, evidence-based approaches are described as key to making decisions that are realistic and based on the needs of the affected community. Hence, data and evidence play a crucial role in driving and finding opportunities to innovate (Fladvad Nielsen et al., 2016; Nelis et al., 2020; Obrecht & Warner, 2016). It is important to tap into appropriate information streams to make suitable evidence-based decisions according to the humanitarian context (Comes et al., 2018; Nelis et al., 2020). The information provided by evaluation findings enables organisations to determine issues and opportunities for improvement in the humanitarian sector, especially when these evaluations involve the views of beneficiaries and affected populations (Obrecht et al., 2017; Bounie et al., 2020). Further, there is increased recognition of the importance of evidence in guiding innovation processes as well as in driving and enabling adoption of humanitarian innovation (Dodgson & Crowley, 2021). Due to the high uncertainty associated with innovation, monitoring and evaluation are considered of particular importance to demonstrate the accountability and effectiveness of innovations (Obrecht & Warner, 2016; Warner, 2017; Obrecht et al., 2017). The paucity of evidence and the need for innovation to identify and help overcome the methodological and operational barriers to delivering humanitarian interventions has led to the development of new programmes, such as the Humanitarian Innovation and Evidence Programme (Nelis et al., 2020), and specific resources for supporting evidence collection on humanitarian innovation (RIL, 2021; Bryant et al., 2019).

The literature stresses evidence-based approaches as key to guiding decisions that are realistic and are directed at the right challenges. Without the proper base for information, it is impossible for donors to know whether their funding

mechanisms achieve the desired policy objectives. Although there is increased knowledge sharing on how to develop evidence on humanitarian innovation and to use it to guide innovation processes, there are no commonly agreed upon procedures and criteria on how evidence should best be collected and analysed. The lack of data and evidence and their standardisation has led to challenges for humanitarian innovation. There exist under-researched topics, such as the potential of operation management to aid humanitarian processes, and little empirical evidence of certain innovations, like mobile clinics or innovations for durable solutions (Nelis et al., 2020; Burke et al., 2016; McGowan et al., 2020; Humanitarian Grand Challenge, 2020). Besides, there is little evidence that can be used by humanitarian innovators to decide on the most suitable resourcing model and few use cases based on hard evidence that can help justify and guarantee scaling (Obrecht & Warner, 2016; European Parliament, 2019). Thus, innovation information needs to be strengthened and more rigorous quality assurance techniques should be implemented to monitor accuracy (Rush et al., 2021; Turk, 2020). A lack of evidence can lead to unintended consequences. For example, as a result of limited involvement and a “hands-off approach”, the Netherlands has failed to adopt a more critical attitude towards the functioning of the agencies receiving its support and the results they achieve (IOB, 2015). Increased donor involvement may help make data and evidence more widely available in humanitarian (IOB, 2015).

7.6. Innovation Skills & Capacities

The literature repeatedly points out that in order to improve the effectiveness and efficiency of innovation in the humanitarian sector, the internal workings of donors and practitioners must become conducive to innovation themselves. The lack of “walking the talk” by donors and practitioners proves an obstacle to innovation efforts. Indeed, while awareness around innovation is increasing throughout the sector, there remains a lack of understanding of the underlying processes, competencies and time required for successful innovation to occur (Gray, 2014). Furthermore, the dominance within the sector of large donors and agencies brings about a lack of R&D funding available to smaller actors in the sector and an inefficient interaction with the private sector. However, there are increased efforts to foster an innovative culture within organisations, with for example UNHCR stating that: ‘Our first agenda item is to expand our efforts to build a stronger culture and set of competencies around innovation’ (Earney, 2019). Donors are called upon to create innovative environments and a culture of innovation.

New skills and capabilities are needed to cope with the rapidly evolving humanitarian system. According to UNHCR, the staff or a donor government, NGO, or intergovernmental agency such as the UN must be supported explicitly in their effort to implement an innovation approach (Earney, 2019). Many staff are in need of information on resources and support throughout the cycle, not solely in financial terms but also through mentorship, tools and

training, such as ELRHA's "Humanitarian Innovation Guide" or the "UN Innovation toolkit". Underlining the necessity for improving modes of working practises, the Global Alliance for Humanitarian Innovation (GAHI) argues that to effectively invest in innovation throughout the entire system, rather than investment in individual innovations, a different kind of investment from funding specific innovators is necessary, and donors must therefore develop the necessary capabilities to adequately perform this type of investment (McClure et al., 2018).

Many organisations, notably humanitarian agencies but also donors, face the challenge of building in-house acceptance of innovation activities. Even where innovation is encouraged, field workers often wish to keep their initiatives to themselves rather than sharing what they have learned, for fear of intervention from headquarters (Earney, 2019). An innovation mindset can be fostered through changes in incentives and practices: opportunities to reflect creatively; dialogue that transcends bureaucratic hierarchies; connecting field and technical staff with headquarters and with one another; secondments within other organisations and sectors; greater human resource mobility across organisations; and encouraging rather than punishing early failure as a means of learning (Balestra, 2019). In order to ensure that staff have required skills and capacities, a more concerted investment in staff and training would be necessary, to enable the best available knowledge leveraging and enhancing operations. UNHCR states that its employees need to 'know when, how, and who it takes for innovation to happen. And when they should embark upon an innovation process. They also need the knowledge and expertise to innovate' (Earney, 2019).

Donor organisations are beginning to review structures and regulations that inhibit innovation, such as barriers to movement into and out of the system to acquire new experiences or skills or procurement rules that limit flexibility to pilot alternative products, processes, or partnerships, particularly with the private sector. For instance, USAID aims to enhance critical technical capabilities regarding innovation by improving its organisational structure and reorganizing bureaus and shaping the workforce to create a more field-focused and functionally aligned headquarters that improves efficiency, programmatic coherence, and ultimately enables USAID to more effectively foster self-reliance (USAID, 2019).

7.7. Ethics and Principles

The literature frequently mentions the ethical implications of introducing innovations into novel contexts. On many occasions, innovations, mainly technological ones, are introduced and deployed in humanitarian contexts without first assessing the harms they may cause to human beings and how they comply with the humanitarian imperative of "do no harm" (Sandvik et al., 2017). The increased collection and use of data and evidence in the

humanitarian sector has also raised ethical concerns (Sandvik et al., 2017, Sandvik, 2020). As innovation brings forth considerable uncertainty given the introduction of new processes and strategies, it poses considerable challenges to stakeholders engaged in the innovation process as to how to manage associated risks (either foreseen and unforeseen) and ensure their accountability.

Given the lack of common and implementable ethical guidelines and standards in the context of humanitarian innovation, the literature, calls for an ethical framework to ensure that stakeholders clearly identify ethical issues, guarantee the innovation's respect for human dignity, clarify the level of involvement of end-users, assess harms and benefits guaranteeing no harm to non-beneficiaries, ensure the access to the innovation, and, lastly, implement and scale-up the innovation using evidence-based decision-making (Sheather et al., 2016; McClure et al., 2018; Taylor, 2016; Sandvik, 2020; Lovey et al., 2021). In order to effectively address such ethical challenges associated with innovation, an increasing number of guidelines and toolkits have been developed in recent years to share best practices and lessons learned (Sheather et al., 2016; Owen et al., 2013; Elrha, 2017a; Principles for Digital Development, 2021).

Furthermore, there are technical trade-offs when introducing new technologies in a setting as well as societal implications, resulting in a mismatch between technologies and humanitarian principles (Sahebi et al., 2020; Talhouk et al., 2020). New technologies could further introduce challenges due to, for instance, the lack of suitable infrastructure (Greenwood et al., 2020), and limited technological knowledge of stakeholders (Hossain & Thakur, 2021). There are also specific risks of different technological innovations, due to their dual-use nature. Drones, for example, provide considerable benefits for amongst others transportation and logistics, but could simultaneously be used as weapons (Jeong et al., 2020). There are also uncertainties surrounding data use. Data risks can include, for instance, the selling of personal data of beneficiaries and affected communities, privacy and data ownership concerns, the collection of sensitive demographically identifiable information, and the misuse of data for military purposes, among others (Raftree, 2020; Smith et al., 2020; European Parliament, 2019). Biometrics, for instance, constitute a real danger for the affected community as they entail the collection of extremely identifiable personal data of beneficiaries which can be used ultimately for other purposes, posing cybersecurity and digital risks (Sandvik, 2020). Hence, data risks exist during its collection, storage, and usage (Wang, 2020).

7.8. Humanitarian-Development Nexus Approach

The literature furthermore stresses the necessity of increased collaboration between humanitarian practitioners and development workers. While the concept of creating a humanitarian-development nexus is repeatedly mentioned in the literature on humanitarian innovation, its link to innovation is not explicit. Predominantly, strengthening the ties of humanitarian and development action is portrayed as an innovation in and of itself. Also, the need for increased use of innovation across humanitarian and development spheres is mentioned, implying a shift of innovation's objectives away from quick-fixes of symptomatic problems and towards addressing underlying root causes and offer system- wide long-term solutions.

The humanitarian-development nexus suggests a paradigmatic shift for donors and practitioners from delivering “only” aid as a direct response to crises and towards a more holistic approach. In the literature, the perception prevails that current modus operandi of the humanitarian system, consisting overwhelmingly of meeting needs immediately following a disaster, are insufficient and resulting in the biased, inappropriate and expensive management of crisis ex-post. Instead, donors and humanitarian practitioners are called upon to strengthen the transition from relief to development and improve coordination at the nexus of humanitarian action, development assistance, stabilisation, peace building, and conflict prevention (European Parliament, 2019; Bryant et al., 2019; IASC, 2021; Dalrymple & Thomas, 2021).

According to the literature, this can be accomplished particularly through programming that is premised on predictable, multi-year commitments that is willing to support programs that include risk but enable innovation. Further, strengthening operational links between the approaches of humanitarian assistance, development cooperation and conflict prevention, both within individual organisations and across them leads to greater programme impact. For instance, UN agencies and NGOs with mandates encompassing humanitarian and development work were better able to coordinate and adapt programming to address both immediate needs and longer term issues than those with a limited mandate (Dalrymple & Thomas, 2021).

7.9. The Humanitarian Innovation Market

The functioning of the humanitarian market system is a commonly occurring topic in the literature. The market constellation in the humanitarian sector differs in many ways from private sector markets, as the donors are the primary customers of innovation, not the affected populations. Hence, negative user experience is far less likely to result in the discontinuation of an innovation, as long as the donors remain willing to fund the information. This donor push of innovation may result in less effective, efficient, and appropriate innovations.

This can be, in part, explained by the incentive system in place in humanitarian contexts, i.e. the market structure of the sector. Concretely, the humanitarian markets' customers (in terms of who ends up spending money) are oftentimes not the affected populations or even the practitioners, but rather the donors. A pressing issue related to the meaning of innovation for the sector is therefore to resolve the question of who the "customer" of the innovation is. For most humanitarian agencies, the donor is the customer and the community where the innovation is applied is the beneficiary (Finnigan & Farkas, 2019). As such, innovators provide the best value proposition as perceived by the customer, i.e. the donors. Donors' interests in certain innovations push innovators in that direction. For instance, donor push is among the main factors for the implementation of mobile clinics, which try to solve the lack of healthcare workers. Yet, evidence shows that mobile clinics may not have a better performance than traditional clinics in some humanitarian settings (McGowan et al, 2020). Nevertheless, due to donors pushing this innovation, the chance of repeat business increases. Thus, policies that underpin the funding may inadvertently push and pull humanitarian practitioners and organisations towards practices that inhibit, restrict or stifle effective innovation. Such donor push of innovation may result in less effective, efficient, and appropriate innovations. In contrast to traditional, efficient markets, negative user experience is far less likely to result in the discontinuation of an innovation, because the donors, who are unaware of potential negative aspects, remain willing to fund the innovation. The literature frequently notes that the innovations created are oftentimes "pushed" by donors due to donor-preferences rather than their explicit qualities. Hence, donors need to be aware of this influence and maximise the likelihood of the innovations they fund to concretely benefit the affected population, by insisting on a clear evidence base.

To circumvent the issues arising from the setup of the complex market constellation to decrease focus on innovations catering to needs of donors instead of practitioners and affected populations by providing incentives for humanitarian innovation to cater more explicitly to benefit the affected population, rather than 'just' the donors. Taking this further, Gray et al. (2019) describe that alternative revenue models should be considered to draw a distinction between the target end-users and buyers of humanitarian innovation. One example would be to focus on cash transfers to affected populations and let innovations enter and exit the system through supply and demand. The aim would be to alleviate need by financially capacitating 'humanitarian consumers' through quality financial services. Theoretically, this would redirect demand from institutional donors to end-users. Pushing this forward, humanitarian innovators suggest that aid agencies must be made independent through generation of financial returns: the relationship between donors and aid agencies must be terminated so that a regular market structure is established which directs demand to beneficiaries only.

8. Discussion

The humanitarian innovation sector is widely believed to have the potential to transform humanitarian practices, however, the surveyed literature suggests that the sector is not living up to this potential. Innovation outputs inconsistently add value to humanitarian practices, and the field is plagued with conceptual ambiguity.

One of the key issues identified in the literature is the lack of uniformity and consensus regarding the definition of humanitarian innovation. Without a generally accepted definition, it is challenging to differentiate between what constitutes innovation and what does not. Additionally, there is no holistic definition of success for innovation, making it difficult to assess the significance of innovation to the sector. Therefore, future research should focus on providing clear definitions and explicit analyses of the characteristics of humanitarian innovation.

In terms of practical innovations introduced into the humanitarian sector, the literature notes a clear dominance of innovations on the product and process level. The prevalence of incremental improvements, rather than transformative change throughout the sector, is a result of this. Moreover, relevant data on the performance of innovation is collected and processed inconsistently, and innovations' added value to the humanitarian sector is thus not verifiable.

To address these challenges, the literature suggests multiple approaches that can be adopted to improve the current state of humanitarian innovation. These include closer collaboration between actors involved in the sector, greater inclusivity of affected populations in the innovation process, and an increase in the capabilities of actors in the sector to become more conducive to innovation. To improve the operating principles of actors in the sector, there is a need to pool and prolong financing, more robustly utilise evidence-based decision-making, and apply clearer ethical guidelines, particularly when dealing with new technologies. Additionally, there is a need to evaluate technologies thoroughly for their appropriateness in the sector, as the humanitarian sector is becoming increasingly technophilic. Finally, to broaden the focus of humanitarian innovation, the sector needs to strengthen collaboration with actors outside of the humanitarian system, particularly in the development sector, to leverage complementarities and strengthen long-term resilience among affected populations.

The above suggestions identify potential avenues for improvement of individual facets of the humanitarian innovation sector. It is unclear how they can work in unison and lead to transformational change, as they do not necessarily resolve misalignments between actors, resources, and incentives. Instead, donors and practitioners must go beyond focussing on singular innovations or innovation processes and drive innovations throughout the

entirety of the sector. Adopting a more deliberate and systematic approach can enhance innovation performance and facilitate better learning and cross-pollination of approaches within the sector.

Hence, the primary insight from our review of the literature is that a more comprehensive understanding of the innovation system within the humanitarian aid sector is necessary. The current operating modes, with managing innovations largely on project or portfolio levels, have led to the development of singular products and processes and do not have the desired transformational effect in the sectorenable . Therefore, we suggest to more explicitly approach and manage humanitarian innovation as a system, to aid in understanding the complex and multifaceted factors that shape innovation processes.

An innovation system can be defined as “the evolving set of actors, activities, and artefacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors.” (Granstrand & Holgersson, 2020, p.3). The concept of innovation systems recognises the complex, interdependent, networked, and socially embedded nature of innovation (Rothwell, 1994). Our findings from the literature confirm and extend the conceptualisation of innovation systems by Granstrand and Hogersson (2020). The following four components constitute the humanitarian innovation system:

1. Actors
2. Institutions
3. Contextual Factors
4. Output and Performance

Table 9. summarises each system component and shows how they are related to the findings from the literature

No.	Component	Description of Component	lements of Components(from the Literature)
1	Actors	The various actors within the system, and the roles they play in driving innovation,	Inclusion of the Affected Population
			Collaboration
			Innovation Capacity

2	Institutions	The formal and informal habits and practices in actors' interactions, their relationships, networks. shaping the way things are done within the system and how they inhibit or encourage innovation	Evidence-Based Approaches Modes of Financing The Humanitarian Innovation Market Ethics and Principles
3	Contextual Factors	Factors external to the system, that introduce innovation inputs into the system, Factors external to the system, that introduce innovation inputs into the system, have an effect on the humanitarian innovation system and may cause it to change and evolve "success" they achieve (e.g., in terms of scale and impact).t to change and evolve.	Technological Development
4	Output and Performance	The (types of) innovations resulting terms of scale and impact).	Humanitarian Development Nexus

Table 9: Components of the Humanitarian Innovation System

Various actors that are active in the space of humanitarian innovation, such as practitioners, policymakers, intermediaries, private sector actors, the affected communities etc., who commission, create, diffuse, and use innovation. The importance of institutions, between these actors, referring for example to the use of evidence-based approaches, modes of financing, the structure of the market in the humanitarian sector, and the adherence to ethics and principles, is also highlighted frequently. Additionally, the humanitarian innovation system

is influenced by contextual factors, which constitute inputs into the system stemming from the wider environment, i.e. other (innovation) systems. For instance, technologies developed in other innovation systems may enter the humanitarian innovation system and be used or altered by humanitarian actors. Contextual factors may also cause the system to change and evolve. The actors, institutions, and contextual factors dictate the performance of the humanitarian innovation system and therewith its ability to achieve the desired transformational change. The specific performance outputs are conceptual (definitions) or tangible (innovation outputs, strategies, targets) in nature. Those involved in humanitarian assistance need to more explicitly acknowledge the interrelationship between these components, knowing that attempting to improve only one aspect of the system while neglecting the others, may not lead to the desired outcomes. Figure 7 displays the humanitarian innovation system.

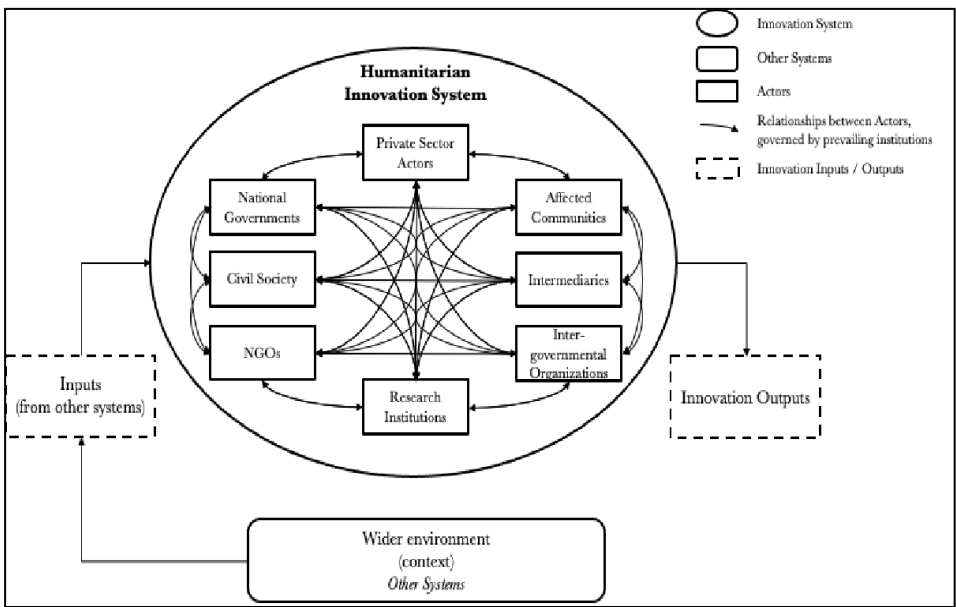


Figure 7: The Humanitarian Innovation System

Conceptualising humanitarian innovation as a system is an important step in improving its performance as it allows for a more comprehensive understanding of the innovation process and the factors that contribute to its success or failure.

Additionally, for humanitarian innovation to achieve transformative impact, it is imperative that it remains true to its roots. The current trend towards prioritising innovation for its own sake over the humanitarian principles of “doing no harm” and alleviating the suffering of those affected by crises, undermines the potential for transformation and the development of effective and sustainable solutions. To address this, there is a need for the realignment of

innovation within the humanitarian sector to focus on its fundamental mission of humanitarianism. This can be achieved through the explicit adoption of a mission-based innovation system, which provides a framework for the development of innovative solutions that are specifically tailored to the most pressing needs of a particular community or population (Mazzucato, 2021), in this case, those affected by humanitarian crises. Such a system would ensure that innovation efforts are focused on meeting the needs of affected populations rather than simply creating new technologies or solutions for the sake of innovation.

This approach requires a shift from a technology-driven approach to a needs-driven approach, with a focus on co-creating solutions with local communities and prioritising long-term sustainable solutions that address the root causes of crises. By becoming a mission-based innovation system, humanitarian innovation can become a powerful tool for transforming the way we respond to crises and delivering more effective and efficient humanitarian aid.

It is important for policymakers to acknowledge the humanitarian innovation system in its entirety and adjust its alignment to become more mission-based for improving the efficiency and effectiveness of the sector. Adopting such a system's perspective can help in identifying possible levers and intervention points for successful innovation, but at the same time requires innovation actors to take a more holistic perspective as to how these are foreseen to drive desired transformational change within the sector. As stated by the UNHCR Innovation Service, systems thinking can aid in gaining 'perspective of a system from all the different stakeholders to see complexity, situational, perceived degree of order to or interconnections' (Neimand & Christiano, 2020). Taking such a systems-based approach is not only beneficial for delivering more effective, efficient, and appropriate solutions to beneficiaries, but also for reforming the humanitarian sector itself by breaking perverse incentives and institutional blockages (Obrecht & Warner, 2016).

9. Conclusion

Humanitarian innovation is not pursued for its own sake: it is meant to lead to substantial improvements in the provision of humanitarian assistance for the benefit of crises affected and crises vulnerable populations. Yet, there is little evidence on the relationship between innovation and humanitarian performance, resulting in ongoing questions as to whether innovation activity is leading to improvements in humanitarian action. The aim of the paper was to analyse the state of academic and practitioner literature on humanitarian innovation, identify themes in the field, and discuss them in the context of a system approach, which was subsequently used to derive policy implications.

The literature study explored several questions related to the concept of humanitarian innovation, to exhibit key concepts and themes. A key takeaway

from the study is that many of the concepts frequently occurring in the humanitarian innovation literature are applied non-uniformly and need clearer definitions. Tellingly, the very definitions of humanitarian innovation are highly varied, applying different focus levels (outcome-based, process-based, system-based etc.) and from being extremely general to very granular. Furthermore, we find that the innovations introduced or proposed in humanitarian contexts tend to be mostly concentrated on the product or process levels, with products often being technology-heavy gadgets that often do not target or correspond to the needs of the affected populations and are primarily managed on a project-level. We also identify the key themes from the literature that are described as drivers or obstacles of humanitarian innovation.

From the review of the literature, the primary insight is that a more holistic view on the sector is necessary, as themes are dispersed and oftentimes not considered concurrently. We therefore develop an innovation system approach, which brings together our findings. This conceptualisation can help policymakers better understand the complexities and interrelationships operating within the system – to see that piecemeal solutions and the introduction of some of the latest trends in the innovation management literature are unlikely to be as effective as hoped, outside of a systemic picture of how innovation works in practice. To enable this, future research should prioritise conducting a detailed analysis of humanitarian innovation systems in different contexts, to provide a better understanding of actors, roles and relationships. Identifying key actors and their roles, across different contexts as well as understanding their interdependencies and dependencies.

For policymakers, an understanding of the innovation system can help identify leverage points for enhancing innovative performance and overall competitiveness. It can assist in pinpointing mismatches within the system, both among institutions and in relation to government policies, which can thwart technology development and innovation. It is furthermore necessary for the sector to discontinue focusing on individual technologies or solution designs as silver bullets, and instead reinvent itself and develop and use the capacity to respond to challenges in the humanitarian sector. Instead, the innovation system must embrace its primary mission of humanitarianism.

We recognise that each component of the framework will require more research to obtain an in-depth and granular understanding of humanitarian innovation. However, there are important lessons that the research has identified, which provides confidence that an ecosystem approach can provide crucial pointers for both practitioners and policymakers in the sector. The findings strongly suggest that without a clear and shared understanding of what humanitarian innovation is and for what it is needed, the how and where of humanitarian innovation will likely remain vague, obscured and difficult to formalise. Therefore, future research needs to endeavour further clarification regarding the key concepts around humanitarian innovation.

Lastly, while there appears to be strong evidence suggesting that local actors and communities are uniquely positioned to innovate in ways that are relevant, effective and culturally and contextually appropriate, localised humanitarian innovation still appears to be under-researched and lacking practical guidelines. The interlink of innovation and localisation should therefore be researched in greater detail. This particularly relates to exploring more closely how knowledge transfer in local contexts is created and fostered, and more broadly how capacities can be built up in crisis contexts.

3. Bibliography

- ALNAP. (2015). Supporting disabled people in emergencies: Motivation's appropriate and affordable wheelchairs - World. In ReliefWeb. <https://reliefweb.int/report/world/supporting-disabled-people-emergencies-motivation-s-appropriate-and-affordable>
- ALNAP. (2018). The State of the Humanitarian System (ALNAP Study). ALNAP/ODI. <https://www.alnap.org/help-library/the-state-of-the-humanitarian-system-2018-full-report>
- Ambruš, D., Vasić, D., & Bilas, V. (2020). Innovating on top of I&M fundamentals for safer humanitarian demining. *IEEE Instrumentation & Measurement Magazine*, 23(3), 35–41.
- Australian Aid. (2016). Humanitarian Strategy. Australian Government. Department of Foreign Affairs and Trade. <https://www.dfat.gov.au/sites/default/files/dfat-humanitarian-strategy.pdf>
- Babatunde, S., Oloruntoba, R., & Agho, K. (2020). Healthcare commodities for emergencies in Africa: Review of logistics models, suggested model and research agenda. *Journal of Humanitarian Logistics and Supply Chain Management*, 10(3). <https://www.emerald.com/insight/content/doi/10.1108/JHLSCM-09-2019-0064/full/html>
- Bahadur, A., & Doczi, J. (2016). Unlocking resilience through autonomous innovation. Overseas Development Institute. <https://cdn.odi.org/media/documents/10245.pdf>
- Balestra, G. (2019). The misfit of innovation [UNHCR Innovation Service]. <https://medium.com/unhcr-innovation-service/the-misfit-of-innovation-f86ac0bf1a9b>
- Benton, M., & Glennie, A. (2016). Digital Humanitarianism: How Tech Entrepreneurs Are Supporting Refugee Integration. Migration Policy Institute. <https://www.migrationpolicy.org/sites/default/files/publications/TCM-Asylum-Benton-FINAL.pdf>
- Bertone, M. P., Jacobs, E., Toonen, J., Akwataghie, N., & Witter, S. (2018). Performance-based financing in three humanitarian settings: Principles and pragmatism. *Conflict and Health*, 12(28). <https://doi.org/10.1186/s13031-018-0166-9>
- Bessant, J. R., & Tidd, J. (2007). Innovation and entrepreneurship. John Wiley & Sons. <https://www.wiley.com/en-us/Innovation+and+Entrepreneurship%2C+3rd+Edition-p-9781118993095>
- Bessant, J., Ramalingam, B., Rush, H., Marshall, N., Hoffman, K., & Gray, B. (2014). Innovation Management, Innovation Ecosystems and Humanitarian Innovation (p. 24). <https://www.alnap.org/system/files/content/resource/files/main/humanitarian-innovation-ecosystem-research-litrev.pdf>

- Bessant, J., Rush, H., & Trifilova, A. (2015). Crisis-driven innovation: The case of humanitarian innovation. *International Journal of Innovation Management*, 19(6). <https://doi.org/10.1142/S1363919615400149>
- Betts, A., & Bloom, L. (2014). Humanitarian Innovation: The State of the Art. UN OCHA. https://www.unocha.org/sites/dms/Documents/OP9_Understanding%20Innovation_web.pdf
- Betts, A., Bloom, L., & Weaver, N. (2015). Refugee Innovation: Humanitarian innovation that starts with communities. Humanitarian Innovation Project, University of Oxford. <https://www.rsc.ox.ac.uk/refugee-innovation-humanitarian-innovation-that-starts-with-communities>
- Bloom, L., & Betts, A. (2013). The two worlds of humanitarian innovation (Working Paper Series No. 94). University of Oxford. <https://www.rsc.ox.ac.uk/publications/the-two-worlds-of-humanitarian-innovation>
- Bloom, L., & Faulkner, R. (2016). Innovation spaces: Lessons from the United Nations. *Third World Quarterly*, 37(8), 1371–1387.
- Bolon, I., Mason, J., O’Keeffe, P., Haeberli, P., Adan, H. A., Karenzi, J. M., Osman, A. A., Thumbi, S. M., Chuchu, V., Nyamai, M., Babo Martins, S., Wipf, N. C., & Ruiz de Castañeda, R. (2020). One Health education in Kakuma refugee camp (Kenya): From a MOOC to projects on real world challenges. *One Health*, 10. <https://doi.org/10.1016/j.onehlt.2020.100158>
- Bounie, D., Arcot, J., Cole, M., Egal, F., Juliano, P., Mejia, C., Rosa, D., & Sellahewa, J. (2020). The role of food science and technology in humanitarian response. *Trends in Food Science & Technology*, 103, 367–375. <https://doi.org/10.1016/j.tifs.2020.06.006>
- Bourne, S. (2019). User-Centred Design and Humanitarian Adaptiveness (ALNAP Case Study). ODI/ALNAP. <https://www.elrha.org/researchdatabase/user-centred-design-and-humanitarian-adaptiveness/>
- Bryant, D. E., Shields-Haas, L. J., Gitta, B., Mohamoud, M. O., Dalmar, A. A., & Jimale, M. A. (2019). Response Innovations for Somalia Emergencies (RISE) – The Innovation Ecosystem Mapping Report. GW/ESIA. <https://reliefweb.int/report/somalia/response-innovations-somalia-emergencies-rise-innovation-ecosystem-mapping-report>
- Burke, T. F., Ahn, R., Nelson, B. D., Hines, R., Kamara, J., Oguttu, M., Dulo, L., Achieng, E., Achieng, B., Natarajan, A., Maua, J., Kargbo, S. A. S., Altawil, Z., Tester, K., de Redon, E., Niang, M., Abdalla, K., & Eckardt, M. J. (2016). A postpartum haemorrhage package with condom uterine balloon tamponade: A prospective multi-centre case series in Kenya, Sierra Leone, Senegal, and Nepal. *An International Journal of Obstetrics and Gynaecology (BJOG)*, 123(9), 1532–1540.
- Caniato, M., Carliez, D., & Thulstrup, A. (2017). Challenges and opportunities of new energy schemes for food security in humanitarian contexts: A selective review. *Sustainable Energy Technologies and Assessments*, 22, 208–219.

- Capgemini Consulting, European Parliament, European Parliamentary Research Service, & Scientific Foresight Unit. (2019). Technological innovation for humanitarian aid and assistance. [http://www.europarl.europa.eu/RegData/etudes/STUD/2019/634411/EPRS_STU\(2019\)634411_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/STUD/2019/634411/EPRS_STU(2019)634411_EN.pdf)
- Chui, C. H.-K., & Ko, A. (2020). Converging humanitarian technology and social work in a public health crisis: A social innovation response to COVID-19 in Hong Kong. *Asia Pacific Journal of Social Work and Development*, 31(1-2), 59-66.
- Clarke, D. J., & Dercon, S. (2016). *Dull Disasters? How planning ahead will make a difference*. Oxford University Press. <http://library.oapen.org/handle/20.500.12657/32368>
- Comes, T., Sandvik, K. B., & Van de Walle, B. (2018). Cold chains, interrupted: The use of technology and information for decisions that keep humanitarian vaccines cool. *Journal of Humanitarian Logistics and Supply Chain Management*, 8(1), 49-69. <https://doi.org/10.1108/JHLSCM-03-2017-0006>
- Corsini, L., & Moultrie, J. (2020). Humanitarian makerspaces in crisis-affected communities. *AI EDAM*, 34(3). <https://www.cambridge.org/core/journals/ai-edam/article/humanitarian-makerspaces-in-crisisaffected-communities/5DEB758016A2F9A0B3A9B5FA4CC86D43>
- Council of the European Union. (2017). Outcome of Proceedings From: General Secretariat of the Council. <https://www.consilium.europa.eu/media/24010/nexus-st09383en17.pdf>
- Curion, P. (2019). The black hole of humanitarian innovation. *Journal of Humanitarian Affairs*, 1(3), 42-45. <https://doi.org/10.7227/JHA.024>
- Dalrymple, S., & Thomas, A. (2021). Supporting longer term development in crises at the nexus Lessons from Somalia report. <https://interagencystandingcommittee.org/system/files/2021-04/Supporting%20longer%20term%20development%20in%20crises%20at%20the%20nexus%20-%20Somalia.pdf>
- Dandurand, G., Claveau, F., Dubé, J.-F., & Millerand, F. (2020). Social Dynamics of Expectations and Expertise: AI in Digital Humanitarian Innovation. *Engaging Science, Technology, and Society*, 6, 591-614.
- DCHI. (2021, March). Supporting student research on mobilising humanitarian innovation for bottom-up results. <https://dchi.nl/news/supporting-student-research-on-mobilising-humanitarian-innovation-for-bottom-up-results/>
- de Winter, D., Lammers, E., & Noort, M. (2019). 33 Showcases – Digitalisation and Development – Inspiration from Dutch development cooperation. IT4D.nl. <https://www.government.nl/documents/publications/2019/10/15/33-showcases---digitalisation-and-development---inspiration-from-dutch-development-cooperation>
- Dehab, M. (2018). Mitigating Operational Challenges in Humanitarian Health Research (p. 1). Elrha. <https://reliefweb.int/sites/reliefweb.int/files/resources/Mitigating-operational-challenges-in-humanitarian-health-research.pdf>

- Detle, R., Steets, J., & Sagmeister, E. (2016). Technologies for monitoring in insecure environments (Secure Access in Volatile Environments (SAVE)). Global Public Policy Institute (GPPi). <https://www.alnap.org/help-library/technologies-for-monitoring-in-insecure-environments>
- Dodgson, K., & Crowley, C. (2021). Impact Evidence and Beyond: Using Evidence to Drive Adoption of Humanitarian Innovations. Elrha. <https://www.elrha.org/researchdatabase/impact-evidence-and-beyond-using-evidence-to-drive-adoption-of-humanitarian-innovations-scaling-series/>
- Dodson, L. L., & Bargach, J. (2015). Harvesting Fresh Water from Fog in Rural Morocco: Research and Impact Dar Si Hmad's Fogwater Project in Aït Baamrane. *Procedia Engineering*, 107, 186–193.
- Earney, C. (2019). For the sake of the future, innovate courageously. [UNHCR Innovation Service]. <https://medium.com/unhcr-innovation-service/for-the-sake-of-the-future-innovate-courageously-4364ccae5c0b>
- Easton-Calabria, E., & Omata, N. (2016). Micro-finance in refugee contexts: Current scholarship and research gaps (Working Paper Series No. 116). Refugee Studies Centre, University of Oxford. <https://www.refworld.org/pdfid/5787a5c44.pdf>
- EIC. (2020). Enhanced European Innovation Council (EIC) pilot. European Innovation Council. https://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-eic_en.pdf
- Elhra. (2017a). R2HC Ethics Framework 2.0. Elrha. <https://www.elrha.org/researchdatabase/r2hc-ethics-framework-2-0/>
- Elrha. (2021). An Update On Our Funding [Elrha]. <https://www.elrha.org/news/an-update-on-our-funding-situation/>
- Elrha. (2017b). Global Prioritisation Exercise for Research and Innovation in the Humanitarian System (Phase One: Mapping). Elrha. https://www.elrha.org/wp-content/uploads/2017/03/Elrha-GPE-Phase-1-Final-Report_Nov-2017.pdf
- Elrha. (2018a). Humanitarian Innovation Guide. Elrha. <https://www.elrha.org/researchdatabase/humanitarian-innovation-guide/>
- Elrha. (2018b). Too tough to scale? Challenges to scaling innovation in the humanitarian sector. Elrha. <https://www.elrha.org/researchdatabase/too-tough-to-scale-challenges-to-scaling-innovation-in-the-humanitarian-sector/>
- European Commission. (2018). Evaluation of Humanitarian Logistics within EU Civil Protection and Humanitarian Action, 2013-2017. European Commission. https://ec.europa.eu/echo/sites/default/files/evaluation_of_transport_and_logistics_-_annexes_1-29.pdf
- European Parliament. (2019). Technological innovation for humanitarian aid and assistance. Panel for the Future of Science and Technology (STOA). [https://www.europarl.europa.eu/RegData/etudes/STUD/2019/634411/EPRS_STU\(2019\)634411_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2019/634411/EPRS_STU(2019)634411_EN.pdf)
- Fekete, A., Bross, L., Krause, S., Neisser, F., & Tzavella, K. (2021). Bridging Gaps in Minimum Humanitarian Standards and Shelter Planning by Critical Infrastructures. *Sustainability*, 13(2). <https://doi.org/10.3390/su13020849>

- Finnigan, G., & Farkas, O. (2019). More than Laboratories: Four Decisive Challenges Confronting Humanitarian Innovation. *Journal of Humanitarian Affairs*, 1(3), 4–13.
- Fladvad Nielsen, B., Sandvik, K. B., & Jumbert, M. G. (2016). How Can Innovation Deliver Humanitarian Outcomes? (PRIO Policy Brief). PRIO. <https://www.prio.org/Publications/Publication/?x=9099>
- Francis, D. L., & Bessant, J. (2005). Targeting Innovation and Implications for Capability Development. *Technovation*, 25(3), 171–183.
- Fund, H. I. (n.d.). Humanitarian Innovation Fund: Frequently Asked Questions. Elrha. <https://www.elrha.org/wp-content/uploads/2015/01/FAQs.pdf>
- Gaffey, M. F., Ataulhajan, A., Das, J. K., Mirzazada, S., Tounkara, M., Dalmar, A. A., & Bhutta, Z. A. (2020). Researching the delivery of health and nutrition interventions for women and children in the context of armed conflict: Lessons on research challenges and strategies from BRANCH Consortium case studies of Somalia, Mali, Pakistan and Afghanistan. *Conflict and Health*, 14(69). <https://doi.org/10.1186/s13031-020-00315-8>
- GAHI. (2019). The Global Alliance of Humanitarian Innovation (GAHI) – Lessons Learned Exercise 2019. Global Alliance for Humanitarian Innovation (GAHI), Elrha. <https://www.alnap.org/help-library/the-global-alliance-of-humanitarian-innovation-gahi-lessons-learned-exercise-2019>
- García-Orosa, B., & Pérez-Seijo, S. (2020). The Use of 360° Video by International Humanitarian Aid Organizations to Spread Social Messages and Increase Engagement. *Voluntas*, 31, 1311–1329.
- Gelsdorf, K., Greenhalgh, L., Morinière, L., Vaughan-Lee, H., Billo, A., & Souders, D. (2017). Global Prioritization Exercise for Research and Innovation in the Humanitarian System. Elrha. https://www.elrha.org/wp-content/uploads/2017/03/Elrha-GPE-Phase-1-Final-Report_Nov-2017.pdf
- Givoni, M. (2016). Between micro mappers and missing maps: Digital humanitarianism and the politics of material participation in disaster response. *Environment and Planning D: Society and Space*, 34(6), 1025–1043.
- Government, A. (n.d.). Australia's assistance for social protection. In Department of Foreign Affairs and Trade. <https://www.dfat.gov.au/aid/topics/investment-priorities/building-resilience/social-protection>
- Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. *Technovation*, 90–91, 102098. <https://doi.org/10.1016/j.technovation.2019.102098>
- Gray, I., Komuhangi, C., McClure, D., & Tanner, L. (2019). Business models for innovators working in crisis response and resilience building: Exploring scalable business models for humanitarian innovation. DEPP Innovation Labs, START Network. <https://startnetwork.org/resource/business-models-innovators-working-crisis-response-and-resilience-building>
- Greenwood, F., Nelson, E. L., & Greenough, P. G. (2020). Flying into the hurricane: A case study of UAV use in damage assessment during the 2017 hurricanes in Texas and Florida. *PLoS ONE*, 15(2). <https://doi.org/10.1371/journal.pone.0227808>

- Heaslip, G., Kovács, G., & Haavisto, I. (2018). Innovations in humanitarian supply chains: The case of cash transfer programmes. *Production, Planning & Control*, 29(14), 1175–1190.
- Heilbrunn, S., & Iannone, R. L. (2020). From Center to Periphery and Back Again: A Systematic Literature Review of Refugee Entrepreneurship. *Sustainability*, 12(18). <https://doi.org/10.3390/su12187658>
- HIF. (2018). Humanitarian Innovation Fund [Elrha]. <https://www.elrha.org/programme/hif/>
- Hill, P. (2018). Innovating around Accountability: A review of innovative initiatives in humanitarian contexts. Save the Children, Innovation Norway. https://resourcecentre.savethechildren.net/node/13476/pdf/innovating_around_accountability_review_final.pdf
- Honig, D. (2019). The Power of Letting Go. *Stanford Social Innovation Review*. <https://www.alnap.org/help-library/the-power-of-letting-go>
- Hossain, Md. K., & Thakur, V. (2021). Benchmarking health-care supply chain by implementing Industry 4.0: A fuzzy-AHP-DEMATEL approach. *Benchmarking: An International Journal*, 28(2), 556–581.
- House, S. (2020). Learning in the Sanitation and Hygiene Sector (SLH Learning Paper 10, The Sanitation Learning Hub). IDS. <https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/15514>
- Hoxtell, W., Norz, M., & Teicke, K. (2015). Business Engagement in Humanitarian Response and Disaster Risk Management PUBLISHED. https://www.gppi.net/media/Hoxtell_et_al_2015_Biz_Engagement_Humanitarian_Response.pdf
- Humanitarian Grand Challenge. (2020). Analysis of Barriers Affecting Innovations in Humanitarian Contexts. A Humanitarian Grand Challenge. <https://humanitariangrandchallenge.org/wp-content/uploads/2021/01/Analysis-of-Barriers-Affecting-Innovation-in-Humanitarian-Contexts.pdf>
- IASC. (2020). Localisation and the Covid-19 Response. Inter-Agency Standing Committee. https://interagencystandingcommittee.org/system/files/2020-11/IASC%20Interim%20Guidance%20on%20Localisation%20and%20the%20COVID-19%20Response_0.pdf
- IASC. (2021). IASC Results Group 5 on Humanitarian Financing. IASC. <https://interagencystandingcommittee.org/system/files/2021-05/Scoping%20Paper-%20IASC%20RG5%20Financing%20Humanitarian-Development%20Collaboration%20Relevant%20to%20Humanitarian%20Actors.pdf>
- IOB. (2015). Policy Review of Dutch Humanitarian Assistance, 2009-2014 (IOB Evaluation). Ministry of Foreign Affairs of the Netherlands. <https://www.government.nl/documents/reports/2015/08/01/iob---policy-review-of-dutch-humanitarian-assistance-2009-2014>
- Iqbal, S. (2017). How we're scaling cutting-edge solutions for the world's toughest classrooms [UNHCR Innovation Service].

<https://www.unhcr.org/innovation/scaling-solutions-worlds-toughest-classrooms/>

- IRC. (2020). A Win-Win: Multi-year flexible funding is better for people and better value for donors. IRC/DI. <https://www.rescue.org/report/win-win-multi-year-flexible-funding-better-people-and-better-value-donors-0>
- Itad. (2014). Evaluation of the Humanitarian Innovation and Evidence Programme (HIEP): Formative Phase Report. Itad, Department for International Development. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/496291/Eval-Humanitarian-Innovation-Evidence-Prog.pdf
- ITU. (2019). Measuring digital development Facts and figures 2019. International Telecommunications Union. <https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2019.pdf>
- Jayasinghe, D., Cobourne, S., Markantonakis, K., Akram, R. N., & Mayes, K. (2018). Philanthropy on the Blockchain. In *Information Security Theory and Practice*. Springer, Cham. https://doi.org/10.1007/978-3-319-93524-9_2
- Jeong, H. Y., Yu, D. J., Min, B.-C., & Lee, S. (2020). The humanitarian flying warehouse. *Transportation Research Part E: Logistics and Transportation Review*, 136(4). <https://doi.org/10.1016/j.tre.2020.101901>
- Jobanputra, K., Greig, J., Shankar, G., Perakslis, E., Kremer, R., Achar, J., & Gayton, I. (2017). Electronic medical records in humanitarian emergencies – The development of an Ebola clinical information and patient management system. *F1000Research*, 5(1477). <https://doi.org/10.12688/f1000research.8287.3>
- Jones, L., & Ballon, P. (2020). Tracking changes in resilience and recovery after natural hazards: Insights from a high-frequency mobile-phone panel survey. *Global Environmental Change*, 62. <https://doi.org/10.1016/j.gloenvcha.2020.102053>
- Kangas, S. T., Salpéteur, C., Nikiéma, V., Talley, L., Ritz, C., Friis, H., Briend, A., & Kaestel, P. (2019). Impact of reduced dose of ready-to-use therapeutic foods in children with uncomplicated severe acute malnutrition: A randomised non-inferiority trial in Burkina Faso. *PLoS Med*, 16(8). <https://doi.org/10.1371/journal.pmed.1002887>
- Karo, B., Haskew, C., Khan, A. S., Polonsky, J. A., Mazhar, M. K. A., & Buddha, N. (2018). World Health Organization Early Warning, Alert and Response System in the Rohingya Crisis, Bangladesh, 2017–2018. *Emerg Infect Dis.*, 24(11), 2074–2076.
- Kasper, G., & Marcoux, J. (2014). The re-emerging art of funding innovation. *Stanford Social Innovation Review*. https://ssir.org/articles/entry/the_re_emerging_art_of_funding_innovation
- Ko, V., & Verity, A. (2016). Blockchain for the Humanitarian Sector: Future Opportunities. *Digital Humanitarian Network, UN OCHA*. <https://reliefweb.int/sites/reliefweb.int/files/resources/BlockChain%20for%20the%20Humanitarian%20Sector%20-%20Future%20Opportunities%20-%20November%202016.pdf>

- Konda, N., Mansour, K., Tanner, L., & Thomas, J. (2019). Human-centred design and humanitarian innovation [Research Paper]. DEPP Innovation Labs. <https://startnetwork.org/resource/human-centred-design-and-humanitarian-innovation>
- Krishnan, S. (2020). Humanitarian WASH (Water, sanitation and hygiene) technologies: Exploring recovery after recurring disasters in Assam, India. *Disaster Prevention and Management: An International Journal*, 29(4), 629– 642. <https://doi.org/10.1108/DPM-02-2019-0051>
- Lawday, A., Poulson, C., & Foley, C. (2017). The Humanitarian Innovation Fund External Evaluation. Elrha. <https://www.elrha.org/wp-content/uploads/2017/09/HIF-Evaluation-submitted.pdf>
- Lazzerini, M., Wanzira, H., Lochoro, P., & Putoto, G. (2019). Improving the quality of care for children with acute malnutrition in Uganda (3ie Impact Evaluation Report 101). International Initiative for Impact Evaluation (3ie). <https://doi.org/10.23846/TW6IE101>
- Lenner, K. (2020). “Biting Our tongues”: Policy Legacies and Memories in the Making of the Syrian Refugee Response in Jordan. *Refugee Survey Quarterly*, 39(3), 273–298.
- Lovey, T., O’Keeffe, P., & Petignat, I. (2021). Basic medical training for refugees via collaborative blended learning: Quasi-experimental design. *Journal of Medical Internet Research*, 23(3). <https://doi.org/10.2196/22345>
- Madianou, M. (2019). Technocolonialism: Digital Innovation and Data Practices in the Humanitarian Response to Refugee Crises. *Social Media + Society*, 5(3). <https://doi.org/10.1177/2056305119863146>
- McClelland, I., & Hill, F. (2019). Exploring a strategic partnership to support local innovation. Humanitarian Practice Network (HPN). <https://odihpn.org/magazine/exploring-strategic-partnership-support-local-innovation/>
- McClure, D., Bourns, L., & Obrecht, A. (2018). Humanitarian Innovation: Untangling the many paths to scale. Global Alliance for Humanitarian Innovation (GAHI). <https://www.elrha.org/wp-content/uploads/2019/07/Humanitarian-Innovation-Untangling-the-Many-Paths-to-Scale-GAHI.pdf>
- McClure, D., & Gray, I. (2015). Scaling: Innovation’s Missing Middle (Transformation Through Innovation). World Humanitarian Summit. <https://www.thoughtworks.com/insights/blog/scaling-innovations-missing-middle>
- McGowan, C. R., Baxter, L., Deola, C., Gayford, M., Marston, C., Cummings, R., & Checchi, F. (2020). Mobile clinics in humanitarian emergencies: A systematic review. *Conflict and Health*, 14(4). <https://doi.org/10.1186/s13031-020-0251-8>
- Menashy, F., & Zakharia, Z. (2020). Private engagement in refugee education and the promise of digital humanitarianism. *Oxford Review of Education*, 46(3), 313–330.

- Metcalf-Hough, V., Fenton, W., Willitts-King, B., & Spencer, A. (2021). The Grand Bargain at five years: An independent review [HPG commissioned report]. ODI. https://cdn.odi.org/media/documents/GB_2021_WEB_YabmhpF.pdf
- Miklian, J., & Hoelscher, K. (2018). A new research approach for Peace Innovation. *Innovation and Development*, 8(2), 189–207.
- Moreno-Serna, J., Sánchez-Chaparro, T., Mazorra, J., Arzamendi, A., Stott, L., & Mataix, C. (2020). Transformational Collaboration for the SDGs: The Alianza Shire's Work to Provide Energy Access in Refugee Camps and Host Communities. *Sustainability*, 12(2). <https://doi.org/10.3390/su12020539>
- Morrow, N., Mock, N., Bauer, J.-M., & Browning, J. (2016). Knowing Just in Time: Use Cases for Mobile Surveys in the Humanitarian World. *Procedia Engineering*, 159, 210–216.
- Mülller, T. R., & Sou, G. (2019). Innovation in Humanitarian Action: Editors' Introduction. *Journal of Humanitarian Affairs*, 1(3), 1–3.
- Munyuzangabo, M., Gaffey, M. F., Khalifa, D. S., Als, D., Ataullahjan, A., Kamali, M., Jain, R. P., Meteke, S., Radhakrishnan, A., Shah, S., Siddiqui, F. J., & Bhutta, Z. A. (2021). Delivering maternal and neonatal health interventions in conflict settings: A systematic review. *BMJ Global Health*, 5(1). <http://dx.doi.org/10.1136/bmjgh-2020-003750>
- Neimand, A., & Christiano, A. (2020). Humanitarian Innovation Needs Systems Thinking – Part 1. UNHCR Innovation Service. <https://medium.com/bending-the-arc/part-one-humanitarian-innovation-needs-systems-thinking-89a0256fca7>
- Nelis, T., Allouche, J., & Sida, L. (2020). The Humanitarian Innovation and Evidence Programme (HIEP): Bringing New Evidence and Methods to Humanitarian Action [Evidence Synthesis]. Institute of Development Studies. <https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/15571>
- Obrecht, A., & Warner, A. (2016). More than just luck: Innovation in humanitarian action (HIF/ALNAP Study). ALNAP/ODI. <https://reliefweb.int/report/world/more-just-luck-innovation-humanitarian-action>
- Obrecht, A., Warner, A., & Dillon, N. (2017). Working paper: Evaluating humanitarian innovation (HIF/ALNAP Working Paper). ODI/ALNAP. <https://www.alnap.org/help-library/evaluating-humanitarian-innovation-hif-alnap-working-paper>
- OCHA (UN Office for the Coordination of Humanitarian Affairs). (2022). Home | Humanitarian Action. [Humanitarian Action.Humanitarianaction.info. https://humanitarianaction.info/](https://humanitarianaction.info/)
- Owen, R., Stilgoe, J., Macnaghten, P., Gorman, M., Fisher, E., & Guston, D. (2013). A Framework for Responsible Innovation. In *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society* (pp. 27–50). John Wiley & Sons. <https://doi.org/10.1002/9781118551424.ch2>
- Oxfam. (2019). We're Listening An evaluation of user-centred community engagement in emergency sanitation. Oxfam.

- <https://reliefweb.int/sites/reliefweb.int/files/resources/gd-listening-community-engagement-emergency-sanitation-050219-summ-en.pdf>
- Oxfam, & WEDC. (2018). Shining a Light: How lighting in or around sanitation facilities affects the risk of gender- based violence in camps. Oxfam, WEDC Loughborough University, HIF. <https://reliefweb.int/report/world/shining-light-how-lighting-or-around-sanitation-facilities-affects-risk-gender-based>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. <https://doi.org/10.1136/bmj.n71>
- Papoulidis, J. (2020). Five ways to build resilience in fragile health systems [The New Humanitarian]. <https://www.thenewhumanitarian.org/opinion/2020/05/13/Fragile-State-Index-global-health>
- Parker, B. (2019). Humanitarian innovation faces rethink as innovators take stock [The New Humanitarian]. <https://www.thenewhumanitarian.org/analysis/2019/03/20/humanitarian-innovation-faces-rethink-innovators-take-stock>
- Parker, B., & Alexander, J. (2021). Aid policy trends to watch in 2021 [The New Humanitarian]. <https://www.thenewhumanitarian.org/analysis/2021/01/04/humanitarian-aid-policy-trends-2021>
- Pascucci, E. (2019). Refugees in the IT Sector: Young Syrians' Economic Subjectivities and Familial Lives in Jordan. *Geographical Review*, 109(4), 580–597.
- Pasha, S. (2020). Developmental Humanitarianism, Resilience and (Dis)empowerment in a Syrian Refugee Camp. *Journal of International Development*, 32(2), 244–259.
- Prasanna, S. R. (2021). The role of supplier innovativeness in the humanitarian context. *Annals of Operations Research*. <https://doi.org/10.1007/s10479-021-04065-5>
- Principles for Digital Development. (2021). Principles for Digital Development. <https://digitalprinciples.org>
- Quattrochi, J., Bisimwa, G., Thompson, T., Van der Windt, P., & Voors, M. (2019). The effects of vouchers for essential household items on child health, mental health, resilience, and social cohesion among internally displaced persons in the Democratic Republic of Congo (Grantee Final Report). International Initiative for Impact Evaluation (3ie). <https://www.gov.uk/research-for-development-outputs/the-effects-of-vouchers-for-essential-household-items-on-child-health-mental-health-resilience-and-social-cohesion-among-internally-displaced-persons-in-the-democratic-republic-of-congo>
- Quinn, J. A., Nyhan, M. M., Navarro, C., Coluccia, D., Bromley, L., & Luengo-Oroz, M. (2018). Humanitarian applications of machine learning with remote-sensing

- data: Review and case study in refugee settlement mapping. *Philosophical Transactions of the Royal Society A*, 376(2128). <https://doi.org/10.1098/rsta.2017.0363>
- Raftree, L. (2020). Digital Safeguarding for Migrating and Displaced Children. Save the Children. <https://reliefweb.int/report/world/digital-safeguarding-migrating-and-displaced-children>
- Ramalingam, B., Rush, H., Bessant, J., Marshall, N., Gray, B., Hoffman, K., Bayley, S., Gray, I., & Warren, K. (2015). Strengthening the Humanitarian Innovation Ecosystem. University of Brighton, Centre for Change, Entrepreneurship and Innovation Management. <https://research.brighton.ac.uk/en/publications/strengthening-the-humanitarian-innovation-ecosystem>
- Ramalingam, B., Scriven, K., & Foley, C. (2009). Innovations in international humanitarian action: ALNAP's 8th Review of Humanitarian Action. ALNAP. <https://www.alnap.org/help-library/innovations-in-international-humanitarian-action-alnaps-8th-review-of-humanitarian>
- Redvers, L. (2017). The "New Way of Working": Bridging aid's funding divide [The New Humanitarian]. <https://www.thenewhumanitarian.org/analysis/2017/06/09/new-way-working-bridging-aid-s-funding-divide>
- Regattieri, A., Gamberi, M., Bortolini, M., & Piana, F. (2018). Innovative Solutions for Reusing Packaging Waste Materials in Humanitarian Logistics. *Sustainability*, 10(5). <https://doi.org/10.3390/su10051587>
- Rejeb, A., & Rejeb, K. (2020). Blockchain and supply chain sustainability. *Logforum*, 16(3). <https://www.logforum.net/volume16/issue3/abstract-3.html>
- Richard, D., & Kiani, S. (2019). Rapid Review of Disability and Older Age Inclusion in Humanitarian WASH Interventions. HIF, Elrha. <https://www.elrha.org/researchdatabase/rapid-review-of-disability-and-older-age-inclusion-in-wash/>
- RIL. (n.d.). Matchmaking [Response Innovation Lab]. <https://www.responseinnovationlab.com/matchmaker>
- RIL. (2021). Innovation Evidence Toolkit [Response Innovation Lab]. <https://www.responseinnovationlab.com/innovation-evidence-toolkit>
- Robinson, A., & Obrecht, A. (2016a). Using mobile voice technology to improve the collection of food security data: WFP's mobile Vulnerability Analysis and Mapping (HIF/ALNAP Case Study). ODI/ALNAP. <https://reliefweb.int/sites/reliefweb.int/files/resources/alnap-wfp-mvam-case-study-2016.pdf>
- Robinson, A., & Obrecht, A. (2016b). Using participation to improve menstrual hygiene management in emergencies: IFRC's MHM kit (HIF/ALNAP Case Study). ODI/ALNAP. <https://www.elrha.org/researchdatabase/using-participation-improve-menstrual-hygiene-management-emergencies-ifrcs-mhm-kit/>
- Rush, H., & Marshall, N. (2015). Case Study: Innovation in Water, Sanitation and Hygiene. UK's Department for International Development (DFID).

<https://reliefweb.int/report/world/case-study-innovation-water-sanitation-and-hygiene>

- Rush, H., Marshall, N., Bessant, J., & Ramalingam, B. (2021). Applying an ecosystems approach to humanitarian innovation. *Technological Forecasting and Social Change*, 165. <https://doi.org/10.1016/j.techfore.2020.120529>
- Sahebi, I. G., Masoomi, B., & Ghorbani, S. (2020). Expert oriented approach for analyzing the blockchain adoption barriers in humanitarian supply chain. *Technology in Society*, 63. <https://doi.org/10.1016/j.techsoc.2020.101427>
- Sandvik, K. B. (2017). Now is the time to deliver: Looking for humanitarian innovation's theory of change. *Journal of International Humanitarian Action*, 2(8). <https://doi.org/10.1186/s41018-017-0023-2>
- Sandvik, K. B. (2019). Do No Harm: Ethical Humanitarian Innovation and Digital Bodies. PRIO, University of Manchester (HCRI), University of Copenhagen, START Network. <https://www.prio.org/Projects/Project/?x=1816>
- Sandvik, K. B. (2020). Wearables for something good: Aid, dataveillance and the production of children's digital bodies. *Information, Communication & Society*, 23(14). <https://doi.org/10.1080/1369118X.2020.1753797>
- Sandvik, K. B., Lindskov Jacobsen, K., & Martin McDonald, S. (2017). Do no harm: A taxonomy of the challenges of humanitarian experimentation. *International Review of the Red Cross*, 99(904), 319–344.
- Schmitt, M. L., Wood, O. R., Clatworthy, D., Rashid, S. F., & Sommer, M. (2021). Innovative strategies for providing menstruation-supportive water, sanitation and hygiene (WASH) facilities: Learning from refugee camps in Cox's bazar, Bangladesh. *Conflict and Health*, 15(10). <https://doi.org/10.1186/s13031-021-00346-9>
- Scott, R. E., & Mars, M. (2015). Telehealth in the developing world: Current status and future prospects. *Smart Homecare Technology and TeleHealth*, 3, 25–37.
- Scott-Smith, T. (2016). Humanitarian neophilia: The 'innovation turn' and its implications. *Third World Quarterly*, 37(12), 2229–2251.
- Seifert, L., Kunz, N., & Gold, S. (2018). Humanitarian supply chain management responding to refugees: A literature review. *Journal of Humanitarian Logistics and Supply Chain Management*, 8(3). <https://www.emerald.com/insight/content/doi/10.1108/JHLSCM-07-2017-0029/full/html>
- Sheather, J., Jobanputra, K., Schopper, D., Pringle, J., Venis, S., Wong, S., & Vincent-Smith, R. (2016). A Médecins Sans Frontières Ethics Framework for Humanitarian Innovation. *PLoS Med*, 13(9). <https://doi.org/10.1371/journal.pmed.1002111>
- Sida. (2015). Support to Innovation and Innovation Systems: Within the Framework of Swedish Research Cooperation. Swedish International Development Cooperation Agency. <https://cdn.sida.se/publications/files/sida61924en-support-to-innovation-and-innovation-systems.pdf>
- Sida. (2019). Support to Innovation and Innovation Systems within the Framework of Swedish Research Cooperation (p. 5). Sida. <https://sidase-wp-files-prod.s3.eu-north->

- 1.amazonaws.com/app/uploads/2020/12/13132034/Support-to-innovation-in-research-cooperation-Sida- position_paper.pdf
- Sida, L., Levine, S., Gray, B., & Cabot Venton, C. (2019). Multi-year humanitarian funding in Ethiopia. In ReliefWeb. Humanitarian Policy Group, ODI, UKaid. <https://cdn.odi.org/media/documents/12791.pdf>
- Skeels, A. (2020). From black hole to north star: A response to the journal of humanitarian affairs special issue on innovation in humanitarian action(JHA, 1:3). *Journal of Humanitarian Affairs*, 2(1), 69–74. <https://doi.org/10.7227/JHA.036>
- Smith, A., Pringle, J., & Hunt, M. (2020). Value-Sensitive Design for Humanitarian Action: Integrating Ethical Analysis for Information and Communication Technology Innovations. In *Ethics of Medical Innovation, Experimentation, and Enhancement in Military and Humanitarian Contexts*. Springer, Cham. https://doi.org/10.1007/978-3-030-36319-2_7
- Spiegel, P., Chanis, R., Scognamiglio, T., & Trujillo, A. (2020). Innovative humanitarian health financing for refugees. In *Health Policy and Systems Responses to Forced Migration* (pp. 35–52). Springer, Cham. https://doi.org/10.1007/978-3-030-33812-1_3
- Talhok, R., Coles-Kemp, L., Jensen, R. B., Balaam, M., Garbett, A., Ghattas, H., Araujo-Soares, V., Ahmad, B., & Montague, K. (2020). Food Aid Technology: The Experience of a Syrian Refugee Community in Coping with Food Insecurity. *Proceedings of the AMC on Human-Computer Interaction*, 4(CSCW2). <https://doi.org/10.1145/3415205>
- Tatham, P., Ball, C., Wu, Y., & Diplas, P. (2017). Long-endurance remotely piloted aircraft systems (LE-RPAS) support for humanitarian logistic operations: The current position and the proposed way ahead. *Journal of Humanitarian Logistics and Supply Chain Management*, 7(1), 2–25.
- Tatham, P., Loy, J., & Peretti, U. (2015). Three dimensional printing – A key tool for the humanitarian logistician? *Journal of Humanitarian Logistics and Supply Chain Management*, 5(2), 188–208.
- Taylor, L. (2016). The ethics of big data as a public good: Which public? Whose good? *Philosophical Transactions of the Royal Society A*, 374(2083). <https://doi.org/10.1098/rsta.2016.0126>
- Turk, C. (2020). Any Portal in a Storm? Collaborative and crowdsourced maps in response to Typhoon Yolanda/Haiyan, Philippines. *Journal of Contingencies and Crisis Management*, 28(4), 416–431.
- UN. (2016). *One Humanity: Shared Responsibility* (Report of the United Nations Secretary-General for the World Humanitarian Summit). United Nations. <http://sgreport.worldhumanitariansummit.org>
- UN. (2019). *The new UN Innovation Toolkit*. UN System Staff College (UNSSC). <https://www.unssc.org/featured- themes/new-un-innovation-toolkit/>
- UN OCHA. (2021). *Global Humanitarian Overview 2021*. United Nations. <https://www.un-ilibrary.org/content/books/9789214030751>
- UN OCHA. (2017a). *OCHA's new Centre for Humanitarian Data a signpost to the future* [UN Office for the Coordination of Humanitarian Affairs].

- <https://www.unocha.org/es/story/ocha%E2%80%99s-new-centre-humanitarian-data-signpost-future>
- UN OCHA. (2017b). The future of technology in crisis response. <https://www.unocha.org/story/future-technology-crisis-response>
- UNHCR. (n.d.). Cluster Approach (IASC) [UNHCR Emergency Handbook]. <https://emergency.unhcr.org/entry/41813/cluster-approach-iasc>
- UNHCR. (2018). Essays from the edge of humanitarian innovation: Year in Review 2017. UNHCR Innovation Service. <https://reliefweb.int/report/world/essays-edge-humanitarian-innovation-year-review-2017>
- USAID. (2019). Transformation at USAID [USAID]. <https://www.usaid.gov/what-we-do/transformation-at-usaid>
- USAID. (2020). Regional Office of Acquisition & Assistance (p. 4). USAID. <https://govtribe.com/file/government-file/3d3f38588f08aff11bf45d6c5c6d7f07>
- Vieille, M. (2020). Op-Ed: Leaving the Valley [Response Innovation Lab]. <https://www.responseinnovationlab.com/tools-publications/leaving-the-valley>
- Wang, N. (2020). “We Live on Hope...”: Ethical Considerations of Humanitarian Use of Drones in Post-Disaster Nepal. *IEEE Technology and Society Magazine*, 39(3), 76–85.
- Warner, A. (2017). Working Paper: Monitoring Humanitarian Innovation. HIF/ALNAP. <https://www.alnap.org/system/files/content/resource/files/main/alnap-hif-innovation-monitoring-2017.pdf>
- Watson, J., Cumming, O., Aunger, R., Deola, C., Chase, R. P., & Dreibelbis, R. (2020). Child handwashing in an internally displaced persons camp in Northern Iraq: A qualitative multi-method exploration of motivational drivers and other handwashing determinants. *PLoS ONE*, 15(2). <https://doi.org/10.1371/journal.pone.0228482>
- Watson, J., Dreibelbis, R., Aunger, R., Deola, C., King, K., Long, S., Chase, R. P., & Cumming, O. (2019). Child’s play: Harnessing play and curiosity motives to improve child handwashing in a humanitarian setting. *International Journal of Hygiene and Environmental Health*, 222(2), 177–182. <https://doi.org/10.1016/j.ijheh.2018.09.002>
- WFP. (2017). Mastercard And The World Food Programme Announce 100 Million Meals Commitment [World Food Programme]. <https://www.wfp.org/news/mastercard-and-world-food-programme-announce-100-million-meals-commitment>
- WHS. (2016). Regional Consultation Latin America and Caribbean, Guatemala, May 5–7, 2015 – Final Report. World Humanitarian Summit. <https://reliefweb.int/report/world/world-humanitarian-summit-regional-consultation-latin-america-and-caribbean-guatemala-0>
- Wilson, M., & Casswell, J. (2018). Recognising Urban Refugees in Jordan: Opportunities for mobile-enabled identity solutions. GSMA, UKaid. https://reliefweb.int/sites/reliefweb.int/files/resources/Recognising_urban_refugees_in_Jordan.pdf

- World Bank. (2018). Maximizing the Impact of the World Bank Group in Fragile and Conflict-Affected Situations. World Bank Group. <https://documents1.worldbank.org/curated/en/855631522172060313/pdf/124654-WP-PUBLIC-MaximizingImpactLowresFINAL.pdf>
- Yankah, E., Mohamed, O., Wringe, A., Afaneh, O., Saleh, M., Speed, O., Hémono, R., Relyea, B., Ibrahim, M., Sandhu, J., & Scott, J. (2020). Feasibility and acceptability of mobile phone platforms to deliver interventions to address gender-based violence among Syrian adolescent girls and young women in Izmir, Turkey. *Vulnerable Children and Youth Studies*, 15(2), 133–143.
- Zwitter, A., & Boisse-Despiaux, M. (2018). Blockchain for humanitarian action and development aid. *Journal of International Humanitarian Action*, 3(16). <https://doi.org/10.1186/s41018-018-0044-5>
- Zwitter, A., & Herman, J. (2018). Blockchain for Sustainable Development Goals: #Blockchain4SDGs—Report 2018. Rijksuniversiteit Groningen. <https://research.rug.nl/en/publications/blockchain-for-sustainable-development-goals-blockchain4sdgs-repo>

No.	Author	Title	Year	Journal	DOI	Link
1	Schmitt M.L., Wood O.R., Olatunji, D., Rashid S.F., Sommer, M.	Innovative strategies for providing menstruation-supportive water, sanitation and hygiene (WASH) facilities: learning from refugee camps in Cox's bazar, Bangladesh	2021	Conflict and Health	10.1186/s13031-021-00346-9	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85101750522&doi=10.1186%2Fs13031-021-00346-9&partnerID=40&md5=ed36415ee8455980c339e46edb148c0a
2	Rush H., Marshall N., Bessent J., Ramalingam B.	Applying an ecosystems approach to humanitarian innovation	2021	Technological Forecasting and Social Change	10.1016/j.techfore.2020.120529	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85099246846&doi=10.1016%2Fj.techfore.2020.120529&partnerID=40&md5=fcd0f46cc74cd934b00de19b0b1d3bde
3	Lovey T., O'Keeffe P., Deligdis I.	Basic medical training for refugees via collaborative blended Learning: Quasi-Experimental Design	2021	Journal of Medical Internet Research	10.2196/22345	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85103551839&doi=10.2196%2F22345&partnerID=40&md5=eed0e83be1739695d8e9dc7244dc15f3
4	Munyuzangabo M., Gaffey M.F., Kholifé D.S., Ali D., Aboukhalil A., Kamali M., Jain R.P., Metelke S., Beletekrishtono A., Shah S., Siddiqui F.J., Bouthe Z.A.	Delivering maternal and neonatal health interventions in conflict settings: A systematic review	2021	BMJ Global Health	10.1136/bmjgh-2020-003750	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85101194672&doi=10.1136%2Fbmjgh-2020-003750&partnerID=40&md5=2ec5334415822ec826d393241e806961
5	Feliste A., Brown L., Krause S., Nejafer F., Tzavella K.	Bridging gaps in minimum humanitarian standards and shelter planning by critical infrastructures	2021	Sustainability (Switzerland)	10.3390/su13020849	https://www.scopus.com/inward/record.uri?eid=2-s2.0-85099805413&doi=10.3390%2Fs13020849&partnerID=40&md5=bff655bd875de5e5de931e9f6e8de5af

6	Beggs, S.R.	The role of supplier innovativeness in the humanitarian context	III	Annals of Operations Research	II1007js 10479-021-04065-5	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3504156493&doi=10.1007/s11116-021-04065-5&recordId=408m45-6341a87a055a471e420c8ac14302572d
7	Udoz G, Bologan Spic L.	Lessons learned from humanitarian logistics to manage supply chain disruptions	III	Journal of Supply Chain Management	II1111js on.112153	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3533174456&doi=10.1111/j.1365-3113.2019.112153.x&recordId=408m45-fb78cc466191a68b91ba09b38c7f0a0d
8	Udo O.	Neocolonialism in the Pacific	III	Big Data and Society	II1177/1 S05171 0985249	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3501134193&doi=10.1177/1070533817305145&recordId=408m45-b8c45901b59ce3bde4f855f49951a537
9	Gedra-Gedra, B, Hec-Gedra, S.	The Use of 360° Video by International Humanitarian Aid Organizations to Speed Social Messages and Increase Engagement	III	Ukrainian	II1007js 11266-020-00280-z	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3504110081&doi=10.1007/s11116-020-00280-z&recordId=408m45-71a9f11a558a7188f0a0f58118e9571
10	Gedra, M.F., Abdullahi, A., Das, J.K., Mousada, S., Gubakara, M., Gubakara, A.A., Buta, I.A.	Researching the delivery of health and nutrition interventions for women and children in the context of armed conflict: lessons on research challenges and strategies from BRANCH Consortium case studies of Somalia, Mali, Pakistan and Afghanistan	III	Conflict and Health	II1186js 13031-020-00315-8	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3533174818&doi=10.1186/s13103-020-00315-8&recordId=408m45-114ba7a761ac0eb10168b30bc824e
11	Gubak, I.G., Mousad, B, Gubak, S.	Spent oriented approach for reducing the Neocolonial adoption barriers in humanitarian supply chain	III	Technology in Society	II1014js techsoc.2 7	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3533174818&doi=10.1016/j.techsoc.2020.101417&recordId=408m45-6f866712419c0f9c0b247338e86a02cb77

12	Hassan, H.K., Thakur V.	Benchmarking healthcare supply chain by implementing Industry 4.0: a fuzzy-ANP-DEMATEL approach	2020	Benchmarking	10.1108/B-11-2019-0265	https://www.emerald.com/insight/fulltext.aspx?doi=10.1108/B-11-2019-0265
13	Tallouk R., Colantoni L., Jomaa R.B., Saleem H., Garbati A., Giaccone H., Douje S., Khatib A., Hachem K.	Food Aid Technology: The Experience of a Syrian Refugee Community in Coping with Food Insecurity	2020	Proceedings of the ACM on Human-Computer Interaction	10.1145/3415225	https://www.acm.org/publications/proceedings-of-the-acm-on-human-computer-interaction
14	Bouso D., Anad J., Cole H., Eyal P., Salano P., Hoja C., Rose D., Balchano J.	The role of food science and technology in humanitarian response	2020	Trends in Food Science and Technology	10.1016/j.tfs.2020.08.008	https://www.sciencedirect.com/science/article/pii/S2468250920305425
15	Saleh S., El-Azouzi H., Alkhouli L., Jomaa R., Hachem K., Douje S.	A scalable model of cloud-based electronic health records for migrating populations in low resource settings	2020	Journal of Medical Internet Research	10.2196/18183	https://www.jmir.org/2020/10/e18183/
16	Krahnert S.	Humanitarian WASH (water, sanitation and hygiene) technologies: exploring recovery after recurring disasters in Assam, India	2020	Disaster Prevention and Management: An International Journal	10.1108/DPM-02-2019-0051	https://www.emerald.com/insight/fulltext.aspx?doi=10.1108/DPM-02-2019-0051
17	Andina D., Vaso D., Bala V.	Innovating on top of the fundamentals for safer humanitarian planning	2020	International Journal of Disaster Management	10.1108/IJDM-01-2020-0027	https://www.emerald.com/insight/fulltext.aspx?doi=10.1108/IJDM-01-2020-0027
18	Jones L., Ballon P.	Tracking changes in resilience and recovery after natural hazards: Insights from a high-frequency mobilephone panel survey	2020	Global Environment Change	10.1016/j.gloenvcha.2020.102053	https://www.sciencedirect.com/science/article/pii/S0924646020305425

19	Jiang, H.Y., Yu D.J, Hu B.-C., Lee S.	The humanitarian flying warehouse	2020	Disaster Medicine and Humanitarian Research Part B: Logistics and Disaster Medicine Review	10.1016/j.dmh.2020.01.001	https://www.sciencedirect.com/journal/disaster-medicine-and-humanitarian-research-part-b-logistics-and-disaster-medicine-reviews
20	McGowan C.R., Batta L, Odeh, C., Gaydos, H., Norton C., Cummings R., Odeh, A.	Mobile clinics in humanitarian emergencies: A systematic review	2020	Conflict and Health	10.1186/s13031-020-00251-8	https://www.sciencedirect.com/journal/conflict-and-health
21	Spiegel P., Odeh R., Bergman, T., Trujillo A.	Innovative humanitarian health financing for refugees	2020	Health Policy and Systems Research to Forced Migration	10.1007/s10312-020-00012-1	https://www.sciencedirect.com/journal/health-policy-and-systems-research-to-forced-migration
22	Rajab, A., Rajab K	Blockchain and supply chain sustainability [Blockchain: a sustainable technology for supply chain management]	2020	Logistics	10.17270/1126-2020.0467	https://www.sciencedirect.com/journal/logistics
23	Horner-Sterne, J; Sanders-Chapman, T; Huxford, J; Aramaki, A; Scott, L; Wolke, C	Transformational Collaboration for the SDGs: The African Union's Work to Provide Energy Access in Refugee Camps and Host Communities	2020	SUSTAINABILITY	10.3390/su12010028	https://www.mdpi.com/journal/sustainability
24	Schmitt, M; Wood, D; Odeh, D; Rashid, S; Samra, M	Innovative strategies for providing menstruation-supplies: water, sanitation and hygiene (WASH) facilities: learning from refugee camps in Cox's bazar, Bangladesh	2021	CONFLICT AND HEALTH	10.1186/s13031-021-00246-9	-
25	Wang, N	We Live on Hope: Ethical Considerations of Humanitarian	2020	IEEE TECHNOLOGY	10.1109/TECH.2020.9123352	-

		Use of Drones in Post-Conflict Recovery		AND SOCIETY MAGAZINE		
26	Barbour, S	Supporting Accountability for Sexual Violence in the Syria and Iraq Conflict: Innovations, Good Practice, and Lessons Learned Through Private Criminal Investigations	2020	JOURNAL OF INTERNATIONAL CRIMINAL JUSTICE	10.1093/iccj/iaa004	-
27	Konieczna, ES; Sobolewski, M; Włodarczyk, L; Włodarczyk, W	The use of funding by Czech and Slovak non-governmental organisations	2020	EUROPEAN JOURNAL OF FUTURES RESEARCH	10.1185/s40309-020-00163-y	-
28	Perler & Alexander	Aid policy trends to watch in 2021	2020	The New Humanitarian	-	https://www.thenewhumanitarian.org/analysis/2021/01/04/humanitarian-aid-policy-trends-2021
29	Geopoulis	Five ways to build resilience in fragile health systems	2020	The New Humanitarian	-	https://www.thenewhumanitarian.org/opinion/2020/05/15/five-ways-to-build-global-health
30	Angela Prando, Edo, Ruth Salmen and Ana Morosini	Innovation to improve monitoring and evaluation for humanitarian GBV programming: An overview of findings from the humanitarian innovation fund's portfolio	2021	EURHA	-	https://hrh.fitch.org/insights/world/innovations-in-humanitarian-gbv-programming-evaluation-humanitarian-innovation-fund-portfolio
31	Save the Children	Digital Safeguarding for Migrating and Displaced Children	2020	Save the Children	-	https://hrh.fitch.org/insights/world/digital-safeguarding-migrating-and-displaced-children
32	Edo, Tina; Włodarczyk, Jeromy; Edo, Livia	Evidence Synthesis: The Humanitarian Innovation and Evidence Programme (HIEP): Bringing New Evidence and Methods to Humanitarian Action	2020	IDS	-	https://hrh.fitch.org/insights/world/evidence-synthesis-humanitarian-innovation-and-evidence-programme-hiep-bringing-new-evidence-and-methods-to-humanitarian-action
33	P. Włodarczyk, Z. Sobolewski	Private engagement in refugee education and the promise of digital humanitarianism	2020	Oxford review of education	-	https://www.oxfordonline.com/doi/abs/10.1093/oxfordre/edres/obaa004

34	KB Baidich	Vulnerability for something good: Aid, dissemination , and the production of children's digital bodies	2020	Information, Communication , and Society	-	https://www.tandfonline.com/doi/full/10.1080/10591429.2020.1754777
35	ABella, L Bloom, N Viscaver	Bottomup humanitarian innovation	2021	UNHCR	-	https://www.unhcr.org/innovation/what-we/bottomupinnovation/
36	P Greenwood, EL Nelson, PG Greenough	Flying into the hurricane: A case study of UAV use in damage assessment during the 2017 hurricane in Texas and Florida	2020	SciDirect	-	https://www.sciencedirect.com/science/article/pii/S1371787120300305
37	L Carony, J Houltrie	Humanitarian robotics , in distressed communities	2020	AI EDAM	-	https://www.cambridge.org/core/journals/ai-edam/article/humanitarian-robotics-in-distressed-communities/30001A001A02F0A001A0000000000000
38	I Baker, J Hixon, P O'Keeffe, P Hausch , HA Aden ...	One Health education in Gakuma refugee camp (Kenya): From a MOOC to projects on real world challenges	2020	One Health	-	https://www.sciencedirect.com/science/article/pii/S2352771420300317
39	E Yankah , O Mohamed, A Wagga ...	Possibility and acceptability of mobile phone platforms to deliver interventions to address gender-based violence among Syrian adolescent girls and young women in ...	2020	Vulnerable Children and Youth Studies	-	https://www.tandfonline.com/doi/full/10.1080/17407613.2019.1647245
40	S Babalola , R Olusolajo , K Agiro	Healthcare commodities for emergencies in Africa: review of logistics models, suggested model and research agenda	2020	Journal of Humanitarian Logistics and Supply Chain Management	-	https://www.emerald.com/insight/article/doi/10.1108/JHLSCM-07-2019-0029-01100
41	KB Baidich	Digital dead body management (DDBM): Time to think it through	2020	Journal of Human Rights Practice	-	https://academic.oup.com/hrj/article/doi/10.1093/hrj/taaa023

30	J Watson, O Cumming, R Aungmye, C Goble, RP Chao...	Child handwashing in an internally displaced persons camp in Northern Iraq: A qualitative, multimethod exploration of motivational drivers and other ...	2020	doi:10.1186/s12938-020-00852-2	https://doi.org/10.1186/s12938-020-00852-2	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7335453/
31	CTurk	Any Resolution-Start? Collaborative and crowdsourced maps in response to Typhoon Yolanda(Yuseo , Philippines)	2020	Journal of Geographics and Crisis Management	https://doi.org/10.1111/j.1468-2468.2020.12321.x	https://onlinelibrary.wiley.com/doi/10.1111/j.1468-2468.2020.12321.x
32	Van Wassenhove , L.N.	Sustainable Innovation: Pushing the Boundaries of Traditional Operations Management	2019	Production and Operations Management	10.1111/poms.13314	https://www.sagepub.com/journals/permissions.nav?j=10.1111/poms.13314&pgs=403&cid=7913&ref=146824682012321&context=146824682012321
33	Rezvani , E.	Refugees in the IT Sector: Young Syrians' Economic Subsidities and Familial Lives in Jordan	2019	Geographical Review	10.1111/gre.12315	https://www.sagepub.com/journals/permissions.nav?j=10.1111/gre.12315&pgs=403&cid=7913&ref=146824682012321&context=146824682012321
34	Haslop G., Kaiser G., Grant D.B.	Sanctification as a competitive difference in humanitarian logistics	2018	Journal of Humanitarian Logistics and Supply Chain Management	10.1108/JHLSCM-08-2017-0042	https://www.sagepub.com/journals/permissions.nav?j=10.1108/JHLSCM-08-2017-0042&pgs=403&cid=7913&ref=146824682012321&context=146824682012321
35	Seifert L, Kure R, Gold B.	Humanitarian supply chain management responding to refugees: a literature review	2018	Journal of Humanitarian Logistics and Supply Chain Management	10.1108/JHLSCM-07-2017-0029	https://www.sagepub.com/journals/permissions.nav?j=10.1108/JHLSCM-07-2017-0029&pgs=403&cid=7913&ref=146824682012321&context=146824682012321
36	Haslop G., Kaiser G., Hasvold L.	Innovations in humanitarian supply chains: the case of cash transfer programmes .	2018	Production Planning and Control	10.1080/09507287.2018.1542172	https://www.sagepub.com/journals/permissions.nav?j=10.1080/09507287.2018.1542172&pgs=403&cid=7913&ref=146824682012321&context=146824682012321

57	Begolliou A., Gamboni M., Bertolini M., Sene P.	Innovative solutions for reusing packaging waste materials in humanitarian logistics	2018	Sustainability (Switzerland)	10.3390/su10051827	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3490708333&doi=10.3390/su10051827&recid=403&md5=334301931c102c91771ac290d718e3e8
58	Begolliou A., Bertolini M., Ferrari E., Gamboni M., Sene P.	Bio gas microproduction from human organic waste-A research proposal	2018	Sustainability (Switzerland)	10.3390/su10051830	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3490708333&doi=10.3390/su10051830&recid=403&md5=1c1ce9e0c709c978071c1c352c3f14
59	Comas T., Bergloun, Sanku K., Van de Walle, S.	Cold chains, interrupted: The use of technology and information for decisions that keep humanitarian vaccines cool	2018	Journal of Humanitarian Logistics and Supply Chain Management	10.1108/JHLSCM-03-2017-0008	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3490432679&doi=10.1108/JHLSCM-03-2017-0008&recid=403&md5=4e04c71838813c0f8c3c0f078e3e00c
60	Quinn J.A., Nelson M.M., Rivera C., Calzada D., Bromley L., Luong-Giac M.	Humanitarian applications of machine learning with remote sensing data: Review and case study in refugee settlement mapping	2018	Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences	10.1098/rsta.2017.0283	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3490017774&doi=10.1098/rsta.2017.0283&recid=403&md5=9444f3886f6d0b0733038280000c8c
61	Asatropos D., Ouloukou S., Wankarandola K., Akam R.N., Hoja K.	Philanthropy on the blockchain	2018	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	10.1007/978-3-319-93524-9_2	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3490470414&doi=10.1007/978-3-319-93524-9_2&recid=403&md5=03c1038e0c07c30000f04c00014c00
62	Garcia M., Carlos D., Chulstrup A.	Challenges and opportunities of new energy schemes for food	2017	Sustainable Energy Technologies	10.1016/j.set.2017.02.008	https://www.scopus.com/inward/record.uri?eid=2-s2.0-3490138807&doi=10.1016/j.set.2017.02.008

70	Dodson LL, Burgess-Limerick R	Harvesting Fresh Water from Fog in Rural Honduras: Research and Impact. Don St. Onofre Burgess-Limerick Project in El Comasano	2015	Bioethics , Engineering	44:463-469 , preprint 10.1101/017315.08.073	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4529720/
71	Scott, RE; Mora, M	Telehealth in the developing world: current status and future prospects	2015	SMART HOMECARE TECHNOLOGY AND TELEMEDICINE	10.2147/S1179-173X.1575184	-
72	Correa L, Anandaraman C; Reulink J	Using digital fabrication tools to provide humanitarian and development aid in low-resource settings	2018	TECHNOLOGY IN SOCIETY	10.1016/j.techsoc.2019.01.003	-
73	Hoyes, B	Migration and data protection: Doing no harm in an age of mass displacement, mass surveillance and big data	2017	INTERNATIONAL REVIEW OF THE RED CROSS	10.1017/S1515388X17000657	-
74	Glasziou J, Liberopoulos K, Scheper D; Fring J; Kara S; Wong S; Vincent-Smith R	A Medical , Data Protection Ethics Framework for Humanitarian Innovation	2018	PLOS MEDICINE	10.1371/journal.pmed.1002111	-
75	Parker	Saving lives and making money: Can humanitarian impact bonds marry the two?	2019	The New Humanitarian	-	https://www.thenewhumanitarian.org/analysis/2019/05/15/humanitarian-impact-bonds
76	Parker	Humanitarian innovation focus rethink as investors take stock	2019	The New Humanitarian	-	https://www.thenewhumanitarian.org/innovation/2019/04/09/humanitarian-innovation-focus-rethink-investors
77	Roberts	The 'New Way of Working': Bridging aid's funding divide	2017	The New Humanitarian	-	https://www.thenewhumanitarian.org/analysis/2017/08/07/new-way-of-working
78	Duffield	Humanitarianism is in crisis. Digital innovation won't fix it	2019	The New Humanitarian	-	https://www.thenewhumanitarian.org/analysis/2019/01/07/humanitarianism-crisis-digital-innovation-wont-fix-it

79	Soson	Why cash as aid risks becoming a passing fad	2015	The New Humanitarian	-	http://www.thenewhumanitarian.org/analysis/2015/04/08/cash-aid-risk-becoming-passing-fad
80	Parker	Maple for good - From the dark web to the light	2015	The New Humanitarian	-	http://www.thenewhumanitarian.org/analysis/2015/03/05
81	George Washington Univ.	Response: Innovations for Somalia Emergencies (RISE) - The Innovation Ecosystem Mapping Report	2019	George Washington Univ.	-	http://linkswatch.info/asset/innovationecosystemmappingreport
82	Oxfam	Response: Listening Through Improved Feedback Mechanisms: End-of-project evaluation	2019	Oxfam	-	http://linkswatch.info/asset/oxfam-response-listening-through-improved-feedback-mechanisms-end-of-project-evaluation
83	Levia Bida , Simon Levine, Bill Gray and Courtney Gabel Norden	Multiyear humanitarian funding in Ethiopia	2019	IOS ODI - HPG	-	http://linkswatch.info/asset/oxfam-multiyear-humanitarian-funding-in-ethiopia
84	Global Alliance for Humanitarian Innovation	The Global Alliance for Humanitarian Innovation - Designing Aid Sector Innovation Labs for More Complex Innovation	2019	Global Alliance for Humanitarian Innovation	-	http://linkswatch.info/asset/globalalliance-humanitarianinnovation-designing-aid-sector-innovation-labs-for-more-complex-innovation
85	SHERIN KIDANE DANIELLE RICHARD	Rapid Review of Disability and Older Age Inclusion in Humanitarian WASH Interventions	2019	EURHA	-	http://linkswatch.info/asset/worldindependent-rapid-review-disability-and-older-age-inclusion-humanitarian-wash-interventions
86	Global Alliance for Humanitarian Innovation	The Global Alliance for Humanitarian Innovation - Diverse Opportunities to Leverage Financial Innovations in Aid	2019	Global Alliance for Humanitarian Innovation	-	http://linkswatch.info/asset/globalalliance-humanitarianinnovation-diverse-opportunities-to-leverage-financial-innovations-in-aid
87	QENIA Mobile for Development	Qeniyang - Urban Refugees in Jordan: Opportunities for mobile-enabled identity solutions	2018	-	-	http://linkswatch.info/asset/qeniyang-urban-refugees-in-jordan-opportunities-for-mobile-enabled-identity-solutions
88	Oxfam	We're Listening: An evaluation of usapoplist community	2019	-	-	http://linkswatch.info/asset/worldindependent-we-re-listening-an-evaluation-of-usapoplist-community

		engaged in emergency sanitation				www.unhcr.org/refugees/innovation">www.unhcr.org/refugees/innovation
89	Don McClure, Lecky Bourne, and Alex O'Rourke	Humanitarian Innovation: Untangling the many paths to scale	2019	Global Alliance for Humanitarian Innovation	-	http://www.dhdc.org/wordpress/wp-content/uploads/2019/07/Humanitarian-InnovationUntangling-the-Many-Paths-to-Scale-GAHI.pdf
90	EURHA HIF Oxford	Shining a Light: How lighting in or around sanitation facilities affects the risk of gender-based violence in camps	2019	EURHA HIF Oxford	-	https://reliefweb.int/report/world/light-shining-way-challenge-account-sanitation-refugees-camp-risk-gender-based
91	EURHA	See Tough To Scale Challenges to scaling innovation in the humanitarian sector	2018	EURHA	-	https://reliefweb.int/report/world/see-tough-to-scale-challenges-scaling-innovation-humanitarian-sector
92	EURHA HIF	Humanitarian Innovation Guide	2018	EURHA	-	https://reliefweb.int/report/world/humanitarian-innovation-guide
93	Digital Humanitarian Network OCHA	ScaleUp for the Humanitarian Sector: Future Opportunities	2018	Digital Humanitarian Network OCHA	-	https://reliefweb.int/report/world/block-chain-humanitarian-sector-future-opportunities
94	EURHA HIF	Humanitarian Innovation Fund Strategy 2018-2020	2018	EURHA Humanitarian Innovation Fund	-	https://reliefweb.int/report/world/humanitarian-innovation-fund-strategy-2018-2020
95	UN High Commissioner for Refugees	Essays from the edge of humanitarian innovation: Year in Review 2017	2017	UN High Commissioner for Refugees	-	https://reliefweb.int/report/world/essays-humanitarian-innovation-year-review-2017
96	HIF Start Network	How to assess the impact of a Drought Risk Financing facility: A guide (October 2017)	2017	HIF, Start Network	-	https://reliefweb.int/report/world/how-assess-impact-drought-risk-financing-facility-guide-october-2017
97	ALNAP	ALNAP Annual Report 2018-2017	2018	ALNAP	-	https://reliefweb.int/report/world/alnap-annual-report-2018-2017
98	ALNAP HIF	Monitoring Humanitarian Innovation	2017	ALNAP HIF	-	https://reliefweb.int/report/world/monitor-humanitarian-innovation

99	Department for International Development UK	Evaluation of Humanitarian Innovation Evidence: Progress (HIEP): Summative Evaluation Phase 1	2017	Department for International Development UK	•	http://reliefweb.int/document/566146/evaluation-evidence-humanitarian-innovation-progress
100	AIHAP HIF	Evaluating Humanitarian Innovation	2017	AIHAP HIF	•	http://reliefweb.int/document/566146/evaluation-evidence-humanitarian-innovation
101	Clifford Nelson, Brito; Kristin Berglöva Sandvik ; & Marie Gabrielsson Lundbeck	How Can Innovation Deliver Humanitarian Outcomes?	2018	Peace Research Institute Oslo (PRIO)	•	http://reliefweb.int/document/566146/evaluation-evidence-humanitarian-innovation
102	AIHAP, Humanitarian Innovation Fund	More than just luck: Innovation in humanitarian action	2018	AIHAP, Humanitarian Innovation Fund	•	http://reliefweb.int/document/566146/evaluation-evidence-humanitarian-innovation
103	World Humanitarian Summit	World Humanitarian Summit - Regional Consultation Latin America and Caribbean, Guatemala, May 3 - 7, 2018	2018	World Humanitarian Summit	•	http://reliefweb.int/document/566146/evaluation-evidence-humanitarian-innovation
104	Joseph Kaplan, Ben Easton/Columbia	Militaries and humanitarian innovation: opportunities and risks	2018	Refugees Studies Centre	•	http://reliefweb.int/document/566146/evaluation-evidence-humanitarian-innovation
105	Alex Robinson with Alex Obiack	Using mobile voice technology to improve the collection of food security data: WFP's mobile Vulnerability Analysis and Mapping	2018	Democratic Republic of the Congo, Somalia	•	http://reliefweb.int/document/566146/evaluation-evidence-humanitarian-innovation
106	AIHAP HIF	A community financing mechanism for disaster risk reduction: The Borrihita approach	2018	AIHAP HIF	•	http://reliefweb.int/document/566146/evaluation-evidence-humanitarian-innovation
107	AIHAP	Words of Relief: Translators without Borders' local language translation for emergencies	2018	AIHAP	•	http://reliefweb.int/document/566146/evaluation-evidence-humanitarian-innovation

117	A Zaidi, M Bhatti, R Okpara	Blockchain for humanitarian action and development aid	2018	Journal of International Humanitarian Action	-	https://humanitarianaction.oxfordjournals.org/doi/10.1093/ihj/ihy018-018-000012
118	TP Burke, R Okpara, SD Nelson, R Hines	A postpartum ~~lactation~~ pedagogy with condom uterine balloon ~~lactation~~ a prospective multi-center case series in Kenya, Sierra Leone, Senegal, and Nepal	2018	International Journal of Obstetrics and Gynecology	-	https://onlinelibrary.wiley.com/doi/10.1111/1471-0528.15559
119	L Taylor	The ethics of big data as a public good: which public ~~data~~ good?	2018	The Royal Society Publishing	-	https://royalsocietypublishing.org/doi/10.1098/rsos.180129
120	J Watson, R Orobello, R Aunger, C Osofsky	Child's play: harnessing play and curiosity motives to improve child ~~handwashing~~ in a humanitarian setting	2019	International Journal of Hygiene and Environmental Health	-	https://www.sciencedirect.com/journal/article/pii/S1631068318300039
121	J Wilson, K Kozicki	A new research approach for Peace Innovation	2018	Innovation and Development	-	https://www.tandfonline.com/doi/abs/10.1080/21577580.2018.1496909
122	L Guerrero-Izquierdo, E Gonzalez-Gutierrez	UV disinfection and flocculation-chlorination systems to reduce hepatitis E virus in drinking water	2018	International Journal of Hygiene and Environmental Health	-	https://www.sciencedirect.com/journal/article/pii/S1631068318300039
123	M Gupta	Between micro mappers and making maps: Digital humanitarianism and the politics of material participation in disaster response	2018	Environment and Planning D: Society and Space	-	https://www.sciencedirect.com/journal/article/pii/S0147177418300039
124	ST Kargbo, C Kojouharova, V Williams, L Tolley	Impact of reduced dose of ready-to-use therapeutic foods in children with uncomplicated severe acute malnutrition: a	2019	BMJ	-	https://www.bmj.com/lookup/doi/10.1136/bmj.n000007

		~~evaluation~~ noninferiority trial in ...				
115	KB Sanduk,	New is the time to deliver: looking for humanitarian innovation's theory of change	2017	Journal of International Humanitarian Action	-	https://humanitarianaction.oxfordjournals.org/doi/10.1093/jihs/aiw017-000002
116	BL Sisonso, TJ Mahan, MW Curtis, JW ~~Sebeaso...~~	Development of a resilient 3-D printer for humanitarian crisis response	2018	Technologia	-	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6199979/
117	S O'Brien	Training translators for crisis communication: translators without borders as an example	2016	Mediating Emergencies and Conflicts	-	https://link.springer.com/chapter/10.1007/978-1-4939-9339-5_4
118	B Kuro, C ~~Haslou~~ , AS Khan, JA ~~Belarukky...~~	World Health Organisation early warning, alert and response system in the Rohingya crisis, Bangladesh, 2017-2018	2018	Emerging ~~infectious~~ ...	-	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6199979/
119	P ~~Tadham~~ , C Bell, Y Wu, P ~~Cople~~	Longitudinal, remotely piloted aircraft systems (L-RPAS) support for humanitarian logistic operations	2017	Journal of Humanitarian Logistics and Supply Chain Management	-	https://www.emerald.com/insight/docui.do?doi=10.1108/JHLSCM-08-2016-0046-0000&fulltext
120	G ~~Cappi~~ , L Post	~~Blockchain~~ and distributed ledger technologies in the humanitarian sector	2019	Overseas Development Institute (ODI)	-	https://www.odi.org/en/handle/10467/16888
121	B ~~Baumlingner~~ , H Rauh, J ~~Seasoul~~ , N Marshall, B Gray...	Strengthening the humanitarian innovation ecosystem	2019	Department for International Development (DFID)	-	https://research.brighton.ac.uk/en/publications/innovation-ecosystem-for-humanitarian-innovation/
122	B ~~Heier-Heier~~ , B ~~Maylla~~	Higher education spaces and protracted displacement: How learner-centered pedagogies and human-centered design can unleash refugee innovation	2018	-	-	https://www.unhcr.org/refugeesanddisplacement/2018/05/20180525

140	M Heinrichs, A Hoogeweg, R Hooper, Q Huck...	Cut the crap: design brief to pre-production in eight weeks: Rapid development of an urban emergency low-cost toilet for Oxfam	2015	Design Studies	-	https://www.researchgate.net/publication/261432990_Cut_the_crap_design_brief_to_pre-production_in_eight_weeks_Rapid_development_of_an_urban_emergency_low-cost_toilet_for_Oxfam
141	P Gahleitner, C Nicol, Y Wu	Hybrid cargo airlifts: a humanitarian logistic game-changer?	2017	Journal of humanitarian logistics and supply chain management	-	https://www.researchgate.net/publication/317220112_Hybrid_cargo_airlifts_a_humanitarian_logistic_game-changer?fulltext=true
142	B Garsington, K Hernandez, P Guala, Martin, B Peeth	Ten Frontier Technologies for international development	2018	Institute of Development Studies	-	https://www.researchgate.net/publication/324131124_Ten_Frontier_Technologies_for_international_development
143	I Gubacka, D Schumann-Gubacka	Mobile phones: Established technologies for innovative humanitarian logistic concepts	2018	Goodlife engineering	-	https://www.researchgate.net/publication/324777694_Mobile_phones_Established_technologies_for_innovative_humanitarian_logistic_concepts
144	M Guevara	A review of cooling systems for humanitarian settings	2018	UNHCR	-	https://www.humanitarianresponse.org/en/default/files/2018/01/Report-1.pdf
145	B Gray, S Gray	Case study: Shelter innovation ecosystem	2018	UK Department for International ...	-	https://www.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/666666/Case-study-MIT-Innovation-Ecosystem.pdf
146	K Grew	Humanitarian innovation and the art of the possible	2018	Humanitarian Exchange	-	https://eh.hio.no/resources/humanitarian-innovation-and-the-art-of-the-possible/
147	JP Kalkman	Practices and consequences of using humanitarian technologies in volatile aid settings	2018	Journal of International Humanitarian Action	-	https://link.springer.com/article/10.1186/s13046-018-0009-z
148	V Wright, M Gahleitner, R Smith, JP Gahleitner	Uganda, Sans Frontières' Clinical guidance: mobile application: analysis of a new electronic health tool	2015	Public Health Action	-	https://www.researchgate.net/publication/261432990_Uganda_Sans_Frontieres'_Clinical_guidance:_mobile_application:_analysis_of_a_new_electronic_health_tool

149	N Hoek, C Engel, W Olanrewaju, J B Desquesnes...	epidemiology : A new contribution to the information ecology of humanitarian work	2018	Proceedings of the 11th International Conference on Humanitarian Information Systems (HIS 2018)	-	https://www.proceedings.com/doc/10.1007/978-3-319-93331-3_23
150	DA Keshler	Refugee entrepreneurship: empirical quantitative evidence on microenterprises in refugee camps in Turkey	2019	Journal of Immigrant & Refugee Studies	-	https://www.tandfonline.com/doi/abs/10.1080/15587545.2019.1677713
151	N Altay, G KÖNİKS	Innovation in Humanitarian Supply Chains: A Systematic Review	2018	Innovation	-	https://www.sagepub.com/journals/online/abstract/10.1177/1469795818765567
152	A Horita, J Freudenberg, J Holten-Jensen	Functional domains of business incubators for refugee entrepreneurs	2019	Journal of Entrepreneurial Communica	-	https://www.sagepub.com/journals/online/abstract/10.1177/2071792019851173
153	World Health Organisation	The global practice of after action review: a systematic review of literature	2019	World Health Organisation	-	https://www.who.int/publications-detail/10.1093/psa/psz014/WHO-WHA-CO-2019-0600001
154	L James	Opportunities and challenges of distributed manufacturing for humanitarian response	2017	2017 IEEE Global Humanitarian Technology ...	-	https://ieeexplore.ieee.org/abstract/document/8249227/
155	TCM Scott-Smith	Beyond the boxes: Refugee shelter and the humanitarian politics of life	2019	American Ethnologist	-	https://www.jstor.org/stable/54661146
156	A Zia-Ul-Haq, J Herman	Blockchain for sustainable development goals. Blockchain4SDGreport 2018	2018	Blockchain4SDG workshop	-	https://www.un.org/development/desa/pubs/files/Blockchain4SDGReport2018.pdf
157	S White, JF Bala, K Desale, T Helm-Jensen	Could the SuperSorbent be used as an alternative hand cleaning product for emergencies? An acceptability and feasibility study in a refugee camp in Ethiopia	2019	Sci&one	-	https://www.sciencedirect.com/science/article/pii/S2468246819300337

158	G Laboy, D Goffman	Heat, light and power for refugees	2019	Saving Lives, Reducing Costs	-	https://www.unhcr.org/refugees/2019/09/online-heat-light-power-refugees-official-report.pdf
159	Chui C.H.-K., Qe A.	Converging humanitarian technology and social work in a public health crisis: a social innovation response to COVID-19 in Hong Kong	2020	Asia Pacific Journal of Social Work and Development	10.1080/01651382.2020.1779041	https://www.tandfonline.com/doi/full/10.1080/01651382.2020.1779041
160	Gordon S.	Regulating humanitarian governance: Humanitarianism and the 'risk society'	2020	Politics and Governance	10.17645/pog.v8i.3130	https://www.unhcr.org/refugees/2020/09/10.17645/pog.v8i.3130
161	K Lasser	"Biting Our Tongues": Policy Legacies and Memories in the Making of the Syrian Refugee Response in Jordan	2020	Refugee Survey Quarterly	-	https://academic.oup.com/rsq/article/doi/10.1093/rsq/fzab010
162	Borik M., Winkler A.	Migration by necessity and by force to mountain areas: An opportunity for social innovation	2018	Mountain Research and Development	10.1658/MRD-JOURNALS-17-00070.1	https://www.unhcr.org/refugees/2018/09/10.1658/MRD-JOURNALS-17-00070.1
163	Bertero M.P., Jacobs E., Eason J., Anagnostou N., Witter S.	Performance-based financing in three humanitarian settings: Principles and progression	2018	Conflict and Health	10.1186/s13031-018-0168-8	https://www.unhcr.org/refugees/2018/09/10.1186/s13031-018-0168-8
164	OCI - Humanitarian Practice Network	Humanitarian Belongs Magazine No. 68 - Feature: Humanitarian Innovation	2018	OCI - Humanitarian Practice Network	-	https://hpn.unhcr.org/feature-humanitarian-innovation

165	ED Barakati	Using digital health to enable ethical health research in conflict and other humanitarian settings	2018	Conflict and Health	-	https://conflictandhealth.biomedcentral.com/articles/10.1186/s13031-018-0163-z
166	Ali Bakh, SA-Badi, J Gubermator...	Developing a camp performance indicator system and its application to Za'atari, Jordan	2018	Journal of Humanitarian Logistics and Supply Chain Management	-	https://www.emerald.com/insight/johl/article/doi/10.1108/JHL-05-2018-002017-0047/full.htm
167	M Gashlwan, El Khay, C KloseGK	Lead User Method vs. Innovation Contest-An Empirical Comparison of Two Open Innovation Methodologies for Identifying Social Innovation for Flood Resilience in ...	2017	Technology and Innovation Management - Hamburg University	-	https://www.unimann.de/forschung-of/article/view/id=30775377
168	Wisseloff, M Bore, K Gocke	Business engagement in humanitarian response and disaster risk management	2015	Global Public Policy Institute	-	https://www.unimann.de/forschung-of/2015/05/2015.pdf
169	Emilia Szepietowska, Ona Dziedach, & Jan Bialos, Barbara	Creating a Culture of Innovation in the Humanitarian Sector	2019	https://doi.org/10.1007/978-94-007-5333-3_10	-	https://link.springer.com/article/10.1007/978-94-007-5333-3_10
170	Peter Biele, Ajoma Christopher & Katie Drew	Five Ethical Principles for Humanitarian Innovation	2019	https://doi.org/10.1007/978-94-007-5333-3_10	-	https://link.springer.com/article/10.1007/978-94-007-5333-3_10
171	Ona Borey & Biele, Kathleen	The Art of Volunteer-Based Innovation for Humanitarian Action	2019	https://doi.org/10.1007/978-94-007-5333-3_10	-	https://link.springer.com/article/10.1007/978-94-007-5333-3_10
172	Badi Barabarauna	Reaching the Last Mile: Distribution Models for Energy Products	2015	https://doi.org/10.1007/978-94-007-5333-3_10	-	https://link.springer.com/article/10.1007/978-94-007-5333-3_10
173	MIT India	TILT: Meeting humanitarian needs through technology	2021	https://doi.org/10.1007/978-94-007-5333-3_10	-	https://link.springer.com/article/10.1007/978-94-007-5333-3_10

174	Max Kella,	OptBD: The Rescuers - How emergencies turn local resources into transformative assets.	2021	https://www.optbd.org/publications	•	https://www.optbd.org/publications/therescuers-how-emergencies-turn-local-resources-into-transformative-assets
175	Quack,	Lessons learned on integrating innovation into the Uganda refugee response	2021	https://www.quack.org/publications	•	https://www.quack.org/publications/lessons-learned-on-integrating-innovation-into-the-uganda-refugee-response
176	Jodi Ashley Fleming	Partnership Potentials: Inspiring Ugandan business attitudes to partnerships with NGOs to create community-based innovations	2020	https://www.potentials.org/publications	•	https://www.potentials.org/publications/inspiring-ugandan-business-attitudes-to-partnerships-with-ngos-to-create-community-based-innovations
177	Piero Uvandi, Lydia Tanner	Building Evidence for Scaling	2020	https://www.buid.org/publications	•	https://www.buid.org/publications/building-evidence-for-scaling
178	Max Kella,	OptBD: Leaving the Valley	2020	https://www.optbd.org/publications	•	https://www.optbd.org/publications/leaving-the-valley
179	Regina Kanda, Chabud Monaur, Lydia Tanner, and Jennie Thomas	Human-Centred Design and Humanitarian Innovation	2019	http://hix.org/publications		http://hix.org/publications/human-centred-design-and-humanitarian-innovation
180	START Network	Drought Insurance for Early Response	2015	http://hix.org/publications	•	http://hix.org/publications/drought-insurance-for-early-response
181	Jonathan Wickett,	APidure is Worth a Thousand Words: Using ~~Blockchain~~ to Monitor Supply Chains	2020	http://hix.org/publications	•	http://hix.org/publications/apidure-is-worth-a-thousand-words-using-blockchain-to-monitor-supply-chains
182	GSMA	Partnership Guidelines: Building effective relationships between FPOs and NGOs in complex environments and crises	2018	https://www.gsma.com/mobilefordevelopment/publications	•	https://www.gsma.com/mobilefordevelopment/publications/partnership-guidelines/

183	GSMA	Business Continuity Management: Planning for disaster readiness in mobile networks	2018	source contents download	-	https://www.gsma.com/mobilefordevelopment/resources/business-continuity-management-for-disaster-readiness-in-mobile-networks/
184	GSMA	The Importance of mobile for refugees: a landscape of new services and approaches	2017	source contents download	-	https://www.gsma.com/mobilefordevelopment/resources/the-importance-of-mobile-for-refugees-a-landscape-of-new-services-and-approaches/
185	GSMA	Refugees and Identity: Considerations for Mobile-enabled Registration and Aid Delivery	2017	source contents download	-	https://www.gsma.com/mobilefordevelopment/resources/refugees-and-identity/
186	GSMA	Humanitarian Payment Optimiser : Focus On Uganda's Bidi Bidi Refugee Settlement	2017	source contents download	-	https://www.gsma.com/mobilefordevelopment/resources/humanitarian-payment-optimiser-focus-on-uganda-s-bidi-bidi-refugee-settlement/
187	GSMA	Displaced and Disconnected	2019	source contents download	-	https://www.gsma.com/mobilefordevelopment/resources/displaced-and-disconnected/
188	GSMA	Mobile-enabled energy for humanitarian contexts	2019	source contents download	-	https://www.gsma.com/mobilefordevelopment/resources/mobile-enabled-energy-for-humanitarian-contexts/
189	GSMA	The Digital Lives of Refugees	2019	source contents download	-	https://www.gsma.com/mobilefordevelopment/resources/the-digital-lives-of-refugees/
190	GSMA	Human-centred design in humanitarian settings: Methodologies for industry	2020	source contents download	-	https://www.gsma.com/mobilefordevelopment/resources/human-centred-design-in-humanitarian-settings/
191	GSMA	Building readiness through mobile-enabled solutions: Lessons from the Mobile for Humanitarian Innovation Fund	2021	source contents download	-	https://www.gsma.com/mobilefordevelopment/resources/building-readiness-through-mobile-enabled-solutions-lessons-from-the-mobile-for-humanitarian-innovation-fund/

192	ICRC	Cash Transfer Programming in Armed Conflict: The ICRC's Experience	2010	https://www.icrc.org/en	-	https://www.icrc.org/en/publications/issue-forces-and-innovations-in-cash-transfer-programming-experience
193	Humanitarian Grand Challenge	Analysis of Barriers Affecting Innovations in Humanitarian Contexts	2010	https://humanitarian.challenge.org	-	https://humanitarian.challenge.org/wp-content/uploads/2011/01/Analysis-of-Barriers-Affecting-Innovations-in-Humanitarian-Contexts.pdf
194	UNHCR Innovation Service	Held the line please, we're improving our call center	2011	https://www.unhcr.org/refugees/article/	-	https://medium.com/unhcr-innovation-service/held-the-line-please-we-re-improving-our-call-center-41c17e48835
195	UNHCR Innovation Service	Innovation Works for Everyone	2010	https://www.unhcr.org/refugees/article/	-	https://medium.com/unhcr-innovation-service/innovation-works-for-everyone-16847e44b1d9
196	UNHCR Innovation Service	On the way to financial inclusion	2010	https://www.unhcr.org/refugees/article/	-	https://medium.com/unhcr-innovation-service/on-the-way-to-financial-inclusion-5049d95e428a
197	UNHCR Innovation Service	The myth of innovation	2019	https://www.unhcr.org/refugees/article/	-	https://medium.com/unhcr-innovation-service/the-myth-of-innovation-f8a6ed7a26
198	UNHCR Innovation Service	Why there's no innovation without experimentation	2019	https://www.unhcr.org/refugees/article/	-	https://medium.com/unhcr-innovation-service/why-there-s-no-innovation-without-experimentation-649244f714b1
199	UNHCR Innovation Service	Weaving innovation through UNHCR's bureaucracy	2019	https://www.unhcr.org/refugees/article/	-	https://medium.com/unhcr-innovation-service/weaving-innovation-through-unhcrs-bureaucracy-c448524ed12c
200	UNHCR Innovation Service	For the sake of the future, innovate courageously	2019	https://www.unhcr.org/refugees/article/	-	https://medium.com/unhcr-innovation-service/for-the-sake-of-the-future-innovate-courageously-13846e9e3e3b
201	UNHCR Innovation Service	How UNHCR Brazil harnessed the power of innovation	2019	https://www.unhcr.org/refugees/article/	-	https://medium.com/unhcr-innovation-service/how-unhcr-brazil-harnessed-the-power-of-innovation-61e10a68e6d4

202	UNICEF Innovation Source	The Void: Building Trust for Artificial Intelligence in the humanitarian context	2019	https://www.unicef.org/innovation/	-	https://medium.com/@unicefinnovation/void-the-void-building-trust-for-artificial-intelligence-in-the-humanitarian-context-3c36c3d44868
203	UNICEF Innovation Source	Humanitarian innovation and regulatory sandboxes	2019	https://www.unicef.org/innovation/	-	https://medium.com/@unicefinnovation/sandbox-humanitarian-innovation-and-regulatory-sandboxes-2430913ee58a
204	UNICEF Innovation Source	How we're using cutting-edge solutions for the world's toughest classrooms	2017	https://www.unicef.org/innovation/	-	https://www.unicef.org/innovation/en/what-we-are-doing-in-the-worlds-toughest-classrooms/
205	Clonage	CometCare	2021	https://www.clonage.com	-	https://www.clonage.com/innovation/cometcare
206	Trek Media International	Essex Emergency Dispatch Platform	2021	https://www.trekmedia.com	-	https://www.clonage.com/innovation/essex
207	US Agency for International Development	Golo	2020	https://www.usaid.gov	-	https://www.clonage.com/innovation/golo
208	Unihabit	Open Source Citizen Engagement Software Platform	2020	https://www.unihabit.com	-	https://www.clonage.com/innovation/unihabit
209	Berry Shelter	Good Works Studio	2019	https://www.berryshelter.com	-	https://www.clonage.com/innovation/good-works-studio
210	EarthBeeble	Sustainable Earthon Floor	2019	https://www.earthbeebble.com	-	https://www.clonage.com/innovation/earthbeebble
211	University of Washington	Uquilo Earth-River Flood Inundation Forecasting	2019	https://www.uw.edu	-	https://www.clonage.com/innovation/uquilo-earth-river-flood-inundation-forecasting
212	CARE	UK Aqua Solar - Nanotechnology based SolarTap	2019	https://www.care.org.uk	-	https://www.clonage.com/innovation/aqua-solar
213	HappyPopGo	Happy Top	2021	https://www.happytopgo.com	-	https://www.clonage.com/innovation/happy-top

214	Evidence Action	Dispensers for Safe Water	2021	https://www.evidenceaction.org/	-	https://www.evidenceaction.org/innovation/long-term-safe-water/
215	Wave Gap/Power	Renewable Powered Wave Grids for Rural Lighting	2020	https://www.wavegap.org/	-	https://www.wavegap.org/innovation/long-term-power/
216	SOIL HelD	Cholera : A Social Business Solution to Haiti's Sanitation Crisis	2019	https://www.soilhelld.org/	-	https://www.soilhelld.org/innovation/haiti-helD/
217	RAND Corporation	Mobile-Enabled Sales of Safe Water Ceramic Filters	2019	https://www.rand.org/	-	https://www.rand.org/innovation/long-term-enabled-sales-of-safe-water-ceramic-filters/
218	Sanivision	Delivering Non-Sewered Sanitation Services to Urban Poor	2019	https://www.sanivision.org/	-	https://www.sanivision.org/innovation/long-term-delivering-non-sewered-sanitation-services-to-urban-poor/
219	Sanergy	Low-Cost Sanitation Facilities in Urban Slums	2019	https://www.sanergy.org/	-	https://www.sanergy.org/innovation/long-term/
220	German Federal Foreign Office	Providing more effective assistance: Innovations in humanitarian aid	2021	https://www.gdpr.de/en/innovation/	-	https://www.gdpr.de/en/innovation/long-term-delivering-more-effective-assistance-innovation-in-humanitarian-aid/20210309/
221	OCHA	The State of the World's Cash Report: Cash Transfer Programming in Humanitarian Aid	2018	https://www.ocha.org/en/innovation/		https://www.humanitarianresponse.info/en/topics/cash-transfer-programming-in-humanitarian-aid/20180309/
222	UN OCHA	Humanitarian Innovation Q&A , State of the Art	2014	https://www.unocha.org/innovation/		https://www.unocha.org/innovation/2014/innovation-q&a-state-of-the-art/
223	UN OCHA	Engagement with the private sector	2020	https://www.unocha.org/innovation/		https://www.unocha.org/innovation/long-term-engagement-with-the-private-sector/

124	UN OCHA	The future of technology in crisis response	2017	https://www.unocha.org/uk/files/technology-in-crisis-response		https://www.unocha.org/uk/files/technology-in-crisis-response
125	UN OCHA	The business case for companies to engage in humanitarian response	2017	https://www.unocha.org/uk/files/business-case-for-companies-to-engage-in-humanitarian-response		https://www.unocha.org/uk/files/business-case-for-companies-to-engage-in-humanitarian-response
126	UN OCHA	Centre for Humanitarian Data: Four takeaways from the first year	2018	https://www.unocha.org/uk/files/c4hdata-four-takeaways-from-the-first-year		https://www.unocha.org/uk/files/c4hdata-four-takeaways-from-the-first-year
127	British Foreign, Commonwealth & Development Office	The Humanitarian Innovation and Evidence Programme (HIEP): Bringing New Evidence and Methods to Humanitarian Action: Evidence Synthesis	2020	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/530000/hiep-evidence-synthesis-report-2020.pdf	-	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/530000/hiep-evidence-synthesis-report-2020.pdf
128	British Foreign, Commonwealth & Development Office	The effects of vouchers for essential household items on child health, mental health, resilience, and social cohesion among internally displaced persons in the Democratic Republic of Congo	2019	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/530000/voucher-effects-on-child-health-mental-health-resilience-and-social-cohesion-among-internally-displaced-persons-in-the-democratic-republic-of-congo.pdf	-	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/530000/voucher-effects-on-child-health-mental-health-resilience-and-social-cohesion-among-internally-displaced-persons-in-the-democratic-republic-of-congo.pdf
129	British Foreign, Commonwealth & Development Office	Multi-Year Humanitarian Funding in Ethiopia	2019	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/530000/multi-year-humanitarian-funding-in-ethiopia.pdf	-	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/530000/multi-year-humanitarian-funding-in-ethiopia.pdf

130	British Foreign, Commonwealth & Development Office	Improving the quality of care of children with acute malnutrition in Uganda	2019	https://www.gov.uk/government/news/uk-announces-10-million-pledge-to-improve-the-quality-of-care-for-children-with-acute-malnutrition-in-uganda	•	https://www.gov.uk/government/news/uk-announces-10-million-pledge-to-improve-the-quality-of-care-for-children-with-acute-malnutrition-in-uganda
131	British Foreign, Commonwealth & Development Office	Impacts of the World Food Programme's interventions to treat malnutrition in Niger	2019	https://www.gov.uk/government/news/impacts-of-the-world-food-programme-s-interventions-to-treat-malnutrition-in-niger	•	https://www.gov.uk/government/news/impacts-of-the-world-food-programme-s-interventions-to-treat-malnutrition-in-niger
132	British Foreign, Commonwealth & Development Office	Technology is helping to transform the way the UK delivers aid abroad	2019	https://www.gov.uk/government/news/technology-is-helping-to-transform-the-way-the-uk-delivers-aid-abroad	•	https://www.gov.uk/government/news/technology-is-helping-to-transform-the-way-the-uk-delivers-aid-abroad
133	British Foreign, Commonwealth & Development Office	Potential for Application of a Probabilistic Catastrophic Risk Modelling Framework to Poverty Outcomes	2018	https://www.gov.uk/government/news/potential-for-application-of-a-probabilistic-catastrophic-risk-modelling-framework-to-poverty-outcomes	•	https://www.gov.uk/government/news/potential-for-application-of-a-probabilistic-catastrophic-risk-modelling-framework-to-poverty-outcomes
134	British Foreign, Commonwealth & Development Office	Use of Catastrophic Risk Models in Assessing Sovereign Food Security for Risk Transfer	2019	https://www.gov.uk/government/news/use-of-catastrophic-risk-models-in-assessing-sovereign-food-security-for-risk-transfer	•	https://www.gov.uk/government/news/use-of-catastrophic-risk-models-in-assessing-sovereign-food-security-for-risk-transfer

240	Australian Government Department of Foreign Affairs and Trade	MPAT-OPAT Humanitarian Monitoring and Evaluation Framework for the Pacific	2021	https://www.dfat.gov.au/development/monitoring-evaluation	•	https://www.dfat.gov.au/development/monitoring-evaluation/building-a-stronger-humanitarian-response-and-recovery-from-disasters-humanitarianmonitoring-evaluationframeworkforthe-pacific
241	Australian Government Department of Foreign Affairs and Trade	Australia's development program — performance assessment	2021	https://www.dfat.gov.au/development/monitoring-evaluation	•	https://www.dfat.gov.au/development/performanceassessment
242	Australian Government Department of Foreign Affairs and Trade	Cash Transfers: OPAT Humanitarian Strategy Guidance Note	2017	https://www.dfat.gov.au/development/monitoring-evaluation	•	https://www.dfat.gov.au/development/cash-transfers/cash-humanitarian-strategy-guidance-note
243	Dutch Ministry of Foreign Affairs	33 Shewases - <i>Debatiasen</i> , and Development - Inspiration from Dutch Development Cooperation	2019	https://www.ministerie-voor-buitenlandse-zaken.nl/documenten/foreign-affairs	•	https://www.ministerie-voor-buitenlandse-zaken.nl/documenten/2019/10/15/33-shewases--debatiasen--en-ontwikkeling--inspiratie-van-nederlandse-ontwikkelingssamenwerking
244	Dutch Ministry of Foreign Affairs	PEOPLE FIRST	2019	https://www.ministerie-voor-buitenlandse-zaken.nl/documenten/foreign-affairs	•	https://www.ministerie-voor-buitenlandse-zaken.nl/documenten/2019/04/19/letter-voor-actiesamenwerking-humanitaire-hulp-en-diplomatie
245	Dutch Ministry of Foreign Affairs	IOB - Policy Review of Dutch Humanitarian Assistance, 2009- 2014	2015	https://www.ministerie-voor-buitenlandse-zaken.nl/documenten/foreign-affairs	•	https://www.ministerie-voor-buitenlandse-zaken.nl/documenten/2015/08/01/obv-2009-2014-politiek-nederlandse-humanitaire-assistentie-2009-2014
246	Dutch Ministry of Foreign Affairs	IOB - Gender, peace and security - Evaluation of the Netherlands and UN Security Council resolution 1325	2015	https://www.ministerie-voor-buitenlandse-zaken.nl/documenten/foreign-affairs	•	https://www.ministerie-voor-buitenlandse-zaken.nl/documenten/2015/04/01/obv-evaluatie-nederlandse-bijdrage-actiesamenwerking-1325

255	Alice O'Rourke	Linking communities to innovation: Innovating in ethnic conflict	2016	ELRHA	-	http://www.elrha.org/wp-content/uploads/2017/03/Linking-communities-to-innovation-2016-1.pdf
256	Alice O'Rourke, A Robinson	USING PARTICIPATION TO IMPROVE MENSTRUAL HYGIENE MANAGEMENT IN EMERGENCIES: IPRC'S MH KIT	2016	ELRHA	-	http://www.elrha.org/assets/default/useruploads/innovation/innovation-improving-menstrual-hygiene-manage-ment.pdf
257	ELRHA	GENDER-BASED VIOLENCE INTERVENTIONS: OPPORTUNITIES FOR INNOVATION	2016	ELRHA	-	http://www.elrha.org/wp-content/uploads/2016/11/GBV-report_2_1_16.pdf
258	Oxfam	PARCAP OPEN WATER FILTER	2016	ELRHA	-	http://www.elrha.org/assets/default/useruploads/filters/
259	Griffith Un-	THE POTENTIAL FOR 3D PRINTING WITHIN HUMANITARIAN PROJECTS	2016	ELRHA	-	http://www.elrha.org/assets/default/useruploads/3d-printing-within-humanitarian-projects/
260	Andrew Leach, Genoss, Paulson, Genoss, Policy	The Humanitarian Innovation Fund External Evaluation	2017	ELRHA	-	http://www.alnps.org/files/default/useruploads/humanitarian-innovation-fund-external-evaluation
261	Hill, P.	Innovating Around Accountability: A Review of Innovative Initiatives in Humanitarian Contexts	2018	Innovation Norway, Save the Children	-	http://www.alnps.org/files/default/useruploads/innovating-around-accountability-a-review-of-innovative-initiatives-in-humanitarian-contexts
262	Alexandra T. Warner	Monitoring Humanitarian Innovation: HIF-ANAP working paper	2017	ELRHA	-	http://www.alnps.org/files/default/useruploads/library/monitoring-humanitarian-innovation/hif-anap-working-paper
263	United Nations Children's Fund (UNICEF)	Evaluation of innovation in UNICEF work	2019	United Nations Children's Fund (UNICEF)	-	http://www.alnps.org/files/default/useruploads/library/evaluation-of-innovation-in-unicef-work

264	BLAHA	Water, Sanitation and Hygiene Innovation Catalogue: A Collection of Innovations for the Humanitarian Sector' (link only)	2019	BLAHA	-	https://www.waterforpeople.org/files/2019/05/2019-WASH-Innovation-Catalogue-2019.pdf
265	Gray, L., Kamukungi, C., McClure, D. and Tennet, L.	Business models for innovators working in crisis response and resilience building	2019	The Start Network	-	https://www.start-network.org/library/business-model-info-minn-oxf-ann-washington-washington-and-collaboration-building
266	United Nations Development Programme (UNDP)	Innovative Approach to Assess and Reduce Vulnerability of Nepal's Housing Stock	2018	United Nations Development Programme (UNDP)	-	https://www.start-network.org/library/innovative-approach-to-assess-and-reduce-vulnerability-of-nepal-housing-stock
267	Oxfam	Innovative Electronic Cash Transfer ~~Programme~~ for Emergencies: An Oxfam-Visa case study in the Philippines	2018	Oxfam	-	https://www.start-network.org/library/innovative-electronic-cash-transfer-programme-for-emergencies-an-oxfam-visa-case-study-in-the-philippines
268	~~Harper, D.~~	The Power of letting go	2019	Stanford Social Innovation Review	-	https://www.start-network.org/library/letting-go
269	~~Children's Rights~~	WarChild UK Innovation Report: Meeting the Rights of Children Affected by Armed Conflict	2018	WarChild	-	https://www.start-network.org/library/war-child-uk-innovation-report-meeting-the-rights-of-children-affected-by-armed-conflict
270	Samuel Hall	Innovating mobile solutions for refugees in East Africa	2018	Samuel Hall	-	https://www.start-network.org/library/innovating-mobile-solutions-for-refugees-in-east-africa
271	The Cash Learning Partnership (CLP)	The State of the World's Cash Report: Cash Transfer Programming in Humanitarian Aid	2018	The Cash Learning Partnership (CLP)	-	https://www.start-network.org/library/state-of-the-worlds-cash-report-cash-transfer-programming-in-humanitarian-aid
272	~~Oxfam, Global Land, Resilience~~	Technologies for monitoring in insecure environments	2018	Global Public Safety Institute	-	https://www.start-network.org/library/technologies-for-monitoring-in-insecure-environments

273	IASC	IASC Results Group 3 on Humanitarian Financing	2021	IASC	-	https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf
274	IASC	Development: Advers and the Nexus: Lessons from crises in Bangladesh, Cameroon and Somalia	2021	IASC	-	https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf
275	OCHA	Global Humanitarian Overview 2021	2021	IASC	-	https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf
276	Food and Agriculture Organization of the United Nations	Catalogue of quality funding proposes to the humanitarian response	2020	IASC	-	https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf
277	Child Protection	Street Child & Child Protection AsR : Accelerating localised response to COVID-19: Practical pathways	2020	IASC	-	https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf
278	ICRC	THE ADDED VALUE OF FLEXIBLE FUNDING TO THE ICRC	2020	IASC	-	https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf
279	UNICEF	UNICEF Internal Assessment: Co-ordinating Quality Funding to Implementing Partners	2020	IASC	-	https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf https://interagencyconflictresponse.org/sites/default/files/2021-05/2021IASC%20SG%20Financial%20Group%20Report.pdf

Frugal Innovation and the Value Creation Paradox: Creating Shared and Stakeholder Value

Ashish Gosain

Centre for Studies in Science Policy, Jawaharlal Nehru University, India

1. Introduction

The key aim in this paper is to understand the multiple meanings of frugal innovation and the emergent discourse. For this, we conduct a systematic literature review of the ecosystem approach literature and its intersections with Web of Science database for a period from 2005 till date. In order to take a grounded approach to identifying categories of frugal innovation, in addition, a field study was conducted at IIT, Roorkee, to observe their functioning elements and the nature of innovation, in terms of value creation processes. Theoretically, we look at the ecosystem elements of frugal innovation developed within a model of research that attempts greater connections with the community. The possibilities of co-creation of frugal innovations through developing frugal innovation ecosystems is the chief focus of the Paper. Five specific cases of innovations over the last two years done by a design scientist, who now heads the Sponsored Research and Industrial Consultancy was looked at this instance. Of particular interest, was an adaptive feedback controlled electric hydro dissection device developed under a closed and proprietary development paradigm and the manual accessory for automating the wheelchair deployed under an open science and non-proprietary paradigm in the latter case. The latter case will provide an interesting contrast on the idea of core functionality and reducing complexity of products, thereby dimensionalizing appropriateness from a care perspective rather than a design perspective alone. In addition, it raises the issue of labour displacement and the personalisation of care in an important area of mobility. The industry of choice was that of medical devices which have become important in the recent context of the pandemic and the emphasis is towards dimensionalizing accessibility beyond affordability in a care giving scenario. The involvement of other stakeholders within the same ecosystem working on different areas of wellness and patient outcomes, more specifically, in medical devices is being explored as this Paper develops. In addition, a field study was conducted in respect of Firstly, we explore the developments within the literature on innovation and frugal innovation. This section shall be followed by a section on Ecosystem approach and its relevant intersectionality with frugal innovation. The third section shall involve a synthesis of findings from the case studies conducted in the field study. Lastly, we shall attempt to understand the meanings of frugal

innovation, both from the field, and the literature to support our preliminary conclusions regarding its constituent elements.

Definitions of Innovation in the Emerging Discourse.

Innovation has become a buzz word, yet it is precisely not well-understood. Some refer to change, some to value and others to acceptance. There is a consensus, however that innovation, good or bad, is a desirable thing. Attributing positive causality therefore emerges as a contemporary update to a teleological argument through the emergence of innovation studies. This update has muddled the discursive waters even further. Innovation in this broadest conceptualisation encompassing all kinds of positive outcomes of organised activity, has become vague and difficult to engage with deeply (Rehn and Ortenblad, 2023¹). A more nuanced view is needed to afford space to critical theoretical perspectives. A novel philosophical concept developed originally in ecological studies, namely that of the “hyper object”²The distribution in time and space is so massive, to the point where most things can be seen as an innovation depending on which spatiotemporal position one chooses to occupy. In a sense that transcends specificity, in that things as far apart as a completely new product and a slightly different manner of selling are simultaneously referred with the same term. The argument advanced is ontological and not nihilist. As a result, calls for a more humble ontology have resulted, in the field of object-oriented ontology for innovation. Martin, 2016 points out in his “Twenty Challenges for innovation studies”, a key problem has been the tendency to look only where it is easiest to do so. Innovation studies is taken to task for mainly studying the things that have been easy to study, ignoring the “dark innovation” that exists outside the contemporary domain. The question of studying the dark sides of innovation, that are not merely marginalised for being more difficult to find, but those actively shunned for not fitting in with the existing paradigm (Coad et al., 2021³). Thus, less clarity and a lot more room for debate and challenge is essential to its further development. The promise of the concept of a hyper object needs engagement in a not so streamlined manner, with singular epistemologies, but on the contrary by highlighting the many perspectives, parleys and paradoxes that are a natural outcome of any such engagement. This appears as a call simplistic and limited ways of trying to come to grips with something as grand, as strange, as interobjective and as viscous as innovation is. In the context of healthcare, the dimensions of labour displacement takes a different standpoint of skilling of workers engaged in the use of equipment and machinery, in addition to allowing the care dimensions of health care. An ethical examination is therefore necessary.

Ethical Dimensions of Innovation.

Innovation, howsoever classified, constitutes a novelty which brings about change that affects a variety of human and non-human stakeholders. Any

innovation can cause criticism and/or protests because it more or less brings a dimension of the rejection of existing values, including ethical ones, and thereby harms the position of those who benefit from vested interests related to them (Thomas Taro Lennerfors and Kiyoshi Murata, 2023 in Rehn and Örténblad, 2023⁴). Any innovation can cause criticism and/or protests since it entails a dimension of the rejection of existing values, including ethical ones, and thus harms the position of those who benefit from vested interests related to them. The technological innovation discussed in the Paper deal with relationships between people and relationships between people and non-human actors such as organisations (Bourban and Rochel, 2021⁵) By focusing on the ethics of technological innovation, concerns related to such innovation serve a broader and forward-looking agenda of innovation ethics, based on particular notions thereof.

Innovation optimists, on the one hand, have a pro-innovation bias. The assumption underlying a majority of innovation literature is pre-supposing that innovation is good and, therefore, that resistance to innovation is problematic (Fornstedt, 2021⁶). Historically, the connotations of innovation have changed significantly. The shift occurs from a negative, anti-traditional, and anti-social understanding to a much more positive view where innovation appears as creating new and socially significant values that revolutionize individual lives, communities, and the world, contributing to resolving complex problems and advancing the progress of humankind. The critical voices maintain that the dark sides of innovation should not go unnoticed. Seeing ethics as critical thinking about the central values that emerge through innovation, and how to act when faced with such value conflicts is therefore necessary⁷. Ethics under this conceptualisation includes and goes beyond concerns such as gender equality and environmental sustainability. Ethics appears not only at different pivotal, grandiose events, for example when one decides to develop a technology, but is omnipresent and an ongoing process. The focus on critical thinking does not mean that we neglect the embodied, emotional, relational aspects of ethics, but although acknowledging this as crucial within ethics, also such ethical impulses are not unproblematic and directly acted upon, should be subject to critical thinking (Lennerfors and Murata, 2023 in Rehn and Örténblad, 2023). Unlike its counterpart in responsible research and innovation, there exists a plurality of discussions about innovation ethics in different fields and sub fields such as philosophy of technology, design, as well as in different engineering fields (Bourban and Rochel, 2021). The agenda to create innovation ethics as a field, connecting a variety of ethical discussions about new technology, with a clearer emphasis on normative ethics. The need for an ethics of technological innovation that takes its base in how technology is imbricated with social practices and in turn influences perceptions or actions. The implementation of this in terms of thinking and dialoguing is done during technological development. The contextual factor of competition constitutes a major barrier to innovation ethics in practice.

The influence of various technologies embedded in economic and social systems and daily living settings on actions and judgments is perceivably strong (Imamichi, 2009). Alternatively speaking, technologies shape what we do and how we experience the world and participate in our ways of doing ethics (Verbeek, 2011). In reference to Ihde's concept of technological intentionality, it is argued that technology transforms what we perceive through amplification and reduction. Through its embedded norms, scripts or affordances, technology shapes action. Some actions are invited, while others are inhibited by the very physical characteristics of the technology. Socio-materiality takes the view that any technology is societal in the sense that it developed, interpreted, and deployed through social processes and simultaneously any social activity is enabled by some sort of technological stuff. Therefore, technology does not exist in the world of objective reality but emerges in a certain societal context (Leonardi, 2009). Although this might seem obvious, in debates, technology is distanced from society and claimed to solve a variety of social and environmental ills. Authors refer to this as "technological fetishism", meaning a too intense focus on only the productivity or usefulness of a particular technological artefact or system, while the different contextual factors-economic, political, social, cultural are also contributing to its viability or the problems of technology (Hornborg, 2001⁸). In terms of how to promote ethics in innovation processes, approaches range from autonomous to deliberative, from approaches that concern thinking for yourself to approaches that favour dialogue and discussion. In engineering ethics, a large number of frameworks for ethical decision-making have been developed, for example, drawing on design methodologies, heuristics and structured problem solving (Lennerfors et al., 2020). These step-by-step frameworks that go from problem formulation, information gathering, formulation of alternatives, assessment of alternatives, assessment thereof and a judgment, decision, action, and reflection. Although such frameworks imply that there is bias towards grand decisions made rarely, the approach makes them valuable in day to day, minor decisions which might be required due to an actor facing conflicting interests, affects and values related to innovation (van de Poel and Royakkers, 2011⁹). Here, particularly the trade-offs between design criteria and decisions regarding the acceptability of particular trade-offs is crucial and needs reflection. In terms of the indirect effects of the technology, the assessments of risks and secondary effects and decisions regarding the acceptability need to be made. The assessment of the scripts and political and social visions that are implicit in a design and decisions regarding the desirability of these scripts. A macro level view on the technology under development is necessitated. Lastly, weighing differential impacts on values as well as the likelihood of this impact. The model takes the designer's agency and power as a starting point and emphasizes the thinking process of the designer.

Ethical technology assessment intends to identify adverse effects of technological innovation at an early stage, by means of a continuous dialogue

with technology developers, scaffolded by a set of value concerns: dissemination and use of information, control, influence and power, impact on social contact patterns, privacy, sustainability, gender, human reproduction, minorities and justice, international relations, and impact on human values (Palm and Hansson, 2006¹⁰). In this approach, the values are in focus, while the framework by van de Poel and Royakkers is centred upon the assessment making process.

Deliberative Approaches to innovation

Though nothing hinders the involvement of stakeholders into the mentioned models of technology assessment, there are other models, which focus more on deliberation. Constructive Technology Assessment (CTA) is a method which is based on the view that one cannot find what is an ethically and socially acceptable technology without taking stakeholders' perspectives into account. The tools that CTA encompasses aims at collaboration with a large set of stakeholders, going beyond immediate users of the technology. Such collaborative means are aimed at creating anticipation, reflexivity, and learning. Guidance ethics aims to provide an ongoing discussion about technology development and use (Verbeek and Tijink, 2020). It focusses on ethics from within rather than on what the authors see as an external tone of assessment . CTA is bottom-up ethics, which focuses on the views of stakeholders, rather than only on expert assessment. Furthermore, it claims to be about the positive-concerned with what we want- rather than on the reduction of the negative-what we do not want.

Dialogic approaches are seemingly democratic and inclusive, not all dialogues are ethically unproblematic. Blok (2014) argues that by relying theoretically on a notion of dialogue as harmony, we cannot grasp the realities of the conversational situation. Rather, by focusing on the difference, we can see the role of the dialogue as deconstructing the self in our dialogic responsiveness to others. Rather than focusing on the dialogical situation as one in which we should convince the other, it is staged as the forum where we become responsive towards others. From the philosophy of difference, the purpose of the dialogue is not express oneself, but to be critical towards oneself, that the parties are not given, but emerge within the dialogue; and the starting point of the dialogue is "in the continuous enactment or performance of the dialogue". One should not underestimate the concerns even if dialogue and inclusiveness are promoted superficially.

In terms of an agenda for innovation ethics, it must promote critical thinking and avoid reification of values. Innovation ethics needs to be reflexive about what is called "ethical" and "responsible" related to innovation and need to be culturally sensitive and not present values stemming from a particular region as universally ethical. In addition, innovation ethics needs to focus on care and maintenance of existing values. While focussing on innovation at the

centrestage, one needs to consider the other side of innovation. From the gaze of innovation, innovators as well as users actively chose to not go about following the way things are at the moment. Innovation ethics should throw light on the various ethical goods of different socio- cultural contexts before the particular innovation. Innovation, therefore, tends to stand in contrast to care and maintenance of what exists at present, and this also needs to be included in an innovation ethics to be able to engage in critical thinking about what is at stake when innovating. Innovation ethics is processual and iterative and cannot be invention ethics, which runs the risk of underestimating responsibility in the rest of the technology lifecycle, and how innovators and others can be involved in innovation processes beyond design. Innovation ethics needs to be open to innovation in a variety of contexts. All in all, despite acknowledging the infinite demands of ethics, it still retains its action-oriented nature. In a frugal innovation context, one needs to look at the values informing the discourse before the findings from the field can be understood.

Definitions of Frugal Innovation in the Current Discourse.

In its multiple meanings, frugal innovation provides a fundamental departure from traditional approaches to innovation at resource use, prioritization of user values, its pragmatic counterpart of value creation for the limited numbers or for the many currently underserved, etc. The process for negotiation of values that have their ethical roots with value, an economic counterpart that appears tangibly as the resolution of multiple paradoxes and trade-offs, is easier said than done. A basic organizing principle in this context is the notion of social and economic value and the balance between competing priorities. Even as regards economic value, value theories emphasize the exchange and/or use of values under differing political and economical approaches, differently in different contexts, based on case studies (Schwartz, 2001; Bhaduri and Shaikh, 2018). The value sought to be negotiated often follows an ordering paradigm that prioritizes specific values or dimensions underlying those values that orient themselves in a space and time context. The limitation of such an approach in the individual and collective context is well-known for being static. However, their context and its constant renegotiation with other values and their corresponding dimensions form the interesting process underlying their embodiment. A concept of shared value provides the motivational subtext in the context of the practices of communities, as opposed to individuals undertaking innovation, despite substantive concerns (Dembek et al., 2016¹¹, Porter and Kraemer, 2006, 2011¹²). The departure from traditional values of innovation arises concerning motivations underlying the generation, scope of innovation, its intended user, and their interaction, as also the nature of innovation activity implicated, namely its developmental stages viz., commercialization, diffusion, etc. (see Table 1 below for various definitions). The value proposition and value creation mechanisms have also been focused

on distinguishing innovations in resource-constrained contexts (Zeschky et al., 2011).

Another critical aspect is forming a competitive advantage as an end goal of such endeavors. The value proposition has something to do with the means-ends dichotomy. Of late, there is a tendency to nuance a different form of advantage that arises in such a context, rooted in the values of frugality. The frugality-based advantage is seen in traditional economic actors, based on input-frugality, income-frugality of users, and infrastructural-frugality (Asakawa et al., 2019¹³). The emphasis is on the transferability of these advantages across locations and their sustainability across time. However, it does complement the resource-based view by explaining how the scarcity of external resources, rather than their abundance, can support the advantage of firms. However, the process of re-orienting the innovation process towards this alternative conceptualization of scarcity-based advantages is the result of evolutionary processes and routines that hardwire consumer expectation at the levels of dimensionalizing resource usage as a starting step of operating within constraints, societal and operational (Levanen et al., 2022¹⁴).

These definitions provide a rich source of lines of investigation on multiple accounts and make conceptualization even more difficult. Firstly, there is divergence on the influence of the perspective of the innovator, entrepreneur, and intended user in formulating such definitions and, consequently, the theoretical issues that arise from such narrow definitions. Secondly, the definitions below show whether adaptability is an essential feature of frugal innovation. In addition, how technological features need to address design problems arising from resource scarcity is distinct to developing country contexts. Functional and/or Market features used to describe and distinguish various types of frugal innovation. These accounts have contestations for overlooking the dynamic capability and decisional elements, in addition to the contextual aspects of such types of innovation. A critical conceptual issue is framing frugal innovation as an initiative of individual innovators instead of from organized yet diffuse sources of knowledge such as communities. This positioning of actors clarifies the conceptualization of the innovation process as led by firms motivated by commercial considerations. Owing to conceptual issues associated with shared value, definitions emphasizing means of creating shared value, resultant outcomes, and beneficiaries of these shared value outcomes become pertinent (Dembek et al., 2016).

Regarding its ontological and epistemological properties, definitions view social value creation as an exogenous process comprising simultaneous advances in the communities of operation. In addition, it takes an activity-based perspective concerning the product, value chain, and cluster creation, which appear too stylized in bottom-of-the-pyramid contexts in developing countries. More so, it is contingent on the means and mechanism of social value creation in a manner that parallels the economic processes of conceptualizing value.

Conceptual clarity about means points to a cost-benefit analysis. The developmental stages of frugal innovation raise issues on the scope and basis for decisions about shared value. The exclusion of personal values in this context gives rise to decisional dissonance at various levels.

Regarding outcomes of shared value, social and economic conditions (Porter and Kraemer, 2011) are of primal significance. Social value needs renegotiation on an ongoing basis for the recalibration of outcomes in frugal innovation in the technological evolution context (Dokko, Nigam, and Rosenkopf, 2012). A consequential question is a mechanism by which value creation occurs differently in a social value creation context.

From an operational perspective, the underrepresentation of the social dimension of triple bottom line value creation, in terms of a social-resource-based view of the firm, distinct from a resource-based and natural resource-based perspective. Another aspect relates to the importance of reformulating products and services, as opposed to wholesale reengineering production processes from an appropriateness standpoint. The appropriateness standpoint creates assessment criteria ex-ante from a responsible innovation perspective. A fundamental departure of frugal innovation is that it does away with the assumption of a well-functioning, permanent, tie-based network structure that social networks to begin with in favour of an ecosystem-like approach that incorporates inclusiveness and legitimacy as its initial driving elements.

Source	Definition	Concepts emphasized.
V. Gupta et al., 2011	Frugal innovation is a new Management philosophy that integrates the needs of the bottom-of-pyramid markets as a starting point and works backward to develop appropriate solutions that may be significantly different from existing solutions designed to address the needs of upmarket segments.	Response to contextual Concerns created with resource constraints focused on neglected demographic consumers.

Zeschky et al., 2011	Three types of innovation in resource-constrained environments: cost, good enough, and frugal innovation. They differ based on technology and market novelty.	Value proposition, value Creation mechanism, Market, and functional features are used as differentiators between variants of frugal innovation. Examples include technical and/or market novelty, functionality, and resource scarcity.
Kumar and Puranam, 2012	Six principle-based criteria for identifying frugal innovation, namely, robustness, portability, defeaturing, leapfrog technology, mega-scale production, and service ecosystem.	Scaling and presence of Service ecosystem emphasized.
Y. Bhatti and M. Ventresca, 2012	Frugal innovation is a broad Term encompassing heterogeneous activities providing effective functional solutions to common problems encountered by “the many” with minimal use of resources	The heterogeneous nature of activities provides effective functional solutions to common problems of many resource-constrained contexts.
Bhatti, 2014; Bhatti et al., 2017	Frugal innovation occurs when there is insufficient equipment, qualified personnel, finance, institutional support, or infrastructure while developing innovative solutions.	Supply-side factors, a role for institutions, at the development stage.
Brem and Wolfram, 2014	Frugal innovation has low to Medium sophistication, medium sustainability, and medium emerging market orientation.	

Radjou and Prabhu, 2014; Ratten, 2019	Frugal innovation is doing more with less. The affordable use of products and services is innovated under conditions of resource scarcity.	Process of innovating in an easy-to-use and cost-efficient way. These definitions lack contingent aspects, focusing on a psychological strategy or changing behaviors by seeing resource constraints as not a disadvantage but an opportunity. Mindset denotes the creative hemisphere, where delivery of high quality at lower costs than mainstream solutions. This aligns with the definition in the Economist, 2010 as it indicates frugal innovation as a strategy to rethink the architecture of the production process and use of resources sparingly
Kuo, 2014	Frugal innovation is products and services that focus on crucial needs, spare resource use, and eliminate non-essential design features	Ordering of needs, resource use paradigm, design problem of non-essential features. Used in a developed country context. Emphasizes efficiency, scalability, and innovativeness as a response.
Weyrauch and Herstatt, 2016	Frugal innovation has three defining criteria, namely substantial cost reduction, retaining core functionalities, and optimization of operational features	Cost reduction is a dimension of affordability, having core functions and optimized performance. Sustainability is not an essential feature. Universal. Multidisciplinary criteria are applicable across contexts.

Tiwari, Fischer and Kalogerakis, 2017	FI is a cheaper and ineffective solution for a temporary problem as aspirations for bigger and better are ever-growing.	Transient solutions, cost-sensitive diffusion of innovation, the fallacy of the scale and efficiency versus the effectiveness of functions
Pisoni et al., 2018	Frugal innovation is the production of innovations that maintain quality and added value but is produced using low expenditure.	They are perceived to be analogous to disruptive innovation. Focus on low-income and underserved consumers.
Hossain M., 2016, 2018	The idea of resource scarcity is not limited to consumers at BoP in developing countries alone	Further exploration outside the domain of affordability is necessary. The ability to adapt to contextual concerns is highlighted.
Koerich and Cancellier, 2019	Frugal innovation can target customers in any segment of the economic pyramid who are price-sensitive by choice or looking for more specific products that best meet their real needs.	Price-sensitive consumers in any segment of the economic pyramid, more straightforward products, meeting real needs.
Hindocha et al., 2021 citing Bencsik et al., 2016	Frugal innovation is not a new strategy but is a flexible approach to thinking about repurposing and sustainable resourcing	Resource usage and sustainability.
Winkler et al., 2021	Follows upon Weyrauch and Herstatt, 2016.	Second-degree frugal innovation, criteria-based innovation model
Angot and Ple, 2015; Brem and Aggarwal, 2017; Brule and Munier, 2021	Earlier definitions emphasized reliance on limited and cheaper resources to face resource scarcity. Good Enough Innovation is imperfect adapted innovations that involve simple and essential functions that are	Imperfect adaptation, simple and essential functions, underserved consumers, and low-cost offerings.

	good enough to meet the needs of underserved consumers and are offered at low cost.	
Hossain, 2018; von Janda et al., 2020; Levannen et al (2022)	Frugal innovation is defined as a novel offering that is radically more resource-efficient than current alternatives and still accessible and user-friendly especially to low-income customers.	Radicalness, resource-efficiency, accessibility, and user-friendliness to low-income customers.

analytic approaches provide conventionally. Without those structural relations of power that drive innovation, soft strategies toward steering the innovation process become crucial to innovation as a process. The innovator's standpoint obstructs the intended audience's prioritization from an inclusion perspective. The starting point of defining the underserved consumer as the bottom of the pyramid has seen contextual variations to the fact that the base of the pyramid as an economic unit has been diminishing, yet substantial cost reductions remain key. The values underlying health equity and access mandate a broader conceptualization than product or service offerings, redesign, and reengineering instead of focusing on product development (Hindocha et al., 2021¹⁵). Here the specificities of the healthcare industry on a regional basis become essential in providing contextual and other boundary conditions for the concept of frugal innovation. In addition, the attitudinal and behavioural aspects from the end of the innovator have moved towards that of the intended user. Process-based definitions have recently arisen, emphasizing the shift towards dynamic instead of structural elements. Another promising avenue of frugal innovation is creating shared value, and the means various actors undertake.

A key assumption of these definitions is that the static assumptions underlying values underlying frugal innovation. As a result, they are criticised for not addressing root causes of the societal problems these innovations claim to address (Pansera, 2018¹⁶). Critical perspectives on frugal innovation point out that frugal innovations end up strengthening unequal power structures and marketing models that are socially or environmentally harmful at the local level. Thus, while addressing some of the pressing societal problems, frugal innovations may also maintain the root causes of many such problems (Pansera, 2018). The complexity arising from the societal and operational pressures needs analytical analysis in a distinct manner. Despite the promise of social change connected to this innovation phenomenon, the idea that this type of innovating automatically contributes to solving societal sustainability challenges seems simplistic as the reality in and for which frugal innovations are developed, is

profoundly complex. The contested nature of frugal innovation, the exploration should begin from a multi-dimensional perspective that simultaneously considers both societal and operational implications (Leliveld and Knorrinda, 2018¹⁷). The research on sustainable business models - considers the societal and environmental value that firms produce for their customers and other stakeholders, in addition to typically considered economic value (Stubbs and Cocklin, 2008). This thinking links with shared value creation and triple bottom line as strategies to address diverse societal concerns as part of business development (Keranen, 2017¹⁸). Therefore, addressing both societal and operational pressures simultaneously with business-based solutions requires continuous balancing between multiple, often conflicting aims. Societal pressures involve grand sustainability challenges such as social inequality, environmental problems, and economic imbalances (George et al., 2016¹⁹). Operational pressures refer to a firm's competitive position at a market, potential negative externalities that may cause extra costs or other risks and market failures which may hamper a firm's strategic activities in a specific market. The value proposition²⁰, value creation²¹ and value capture²² are components of business models. Operational pressures related to resource scarcity²³, affordability constraints²⁴ and institutional constraints²⁵ (Bhatti et al., 2018). Innovation that have market traction despite the challenges in their development were studied using three case studies, one of them being namely a firm selling low-cost sanitary napkin-making machines and the raw materials for making the napkins to individuals, NGO's and cooperative societies who can then produce and sell affordable sanitary pads to women in their localities. They enable 22000 women to earn a livelihood and provide access to sanitary pads to more than a million women in India. Each sanitary pad entrepreneur has her own brand name and there are at least 900 brand names. Data on the business model development through thematic interviews, field observations and documentary materials. The value proposition is a unique low-price product or means of production with minimal features but with "good enough quality". The need to address health related problems is a key social aspect. Here, affordability that does not compromise the quality of products is the cornerstone of this value proposition. In the case of healthcare developing value for patient outcomes is defined at the micro-, meso- and macro levels through opportunities and challenges (Kulkov et al., 2023). The micro or individual patient level and the meso- or healthcare personnel level is crucial for the adoption of such innovations.

Case Study of Modular Accessory for automating wheelchair.

Case Study on Pran Vayu, Ventilator Device.

Case Study on Hydro-dissection Device used for left palate surgeries.

Conclusion.

Most importantly, the selection process of specific values that generate effects independent of the elements comprising the entity undertaking innovation stands out in contrast to individualistic and atomistic accounts of networks, configurations, etc. In addition, the concept of shared value offers the promise of alternative ontological forms that underlie knowledge generation, transfer, and diffusion (Porter and Kraemer, 2011). The social and economic conditions of the communities in which it operates overlap partially with the social and economic conditions underlying its exchange. The various attempts have provided orthogonal dimensions of resource usage, complementarities, motivations of differing entities, etc., as a starting point for dimensionalizing the innovation process. However, it has long avoided the question of the conflict resolution mechanism between the extrinsic value of innovation, contingent on environmental factors, and the intrinsic value inherent to an artifact (Schwartz, 2001). The result is the creation of a binary of extremes between high-quality, technological goods on the one hand and good enough solutions on the other. That conceptualization juxtaposes the need for economic value in contrast with social value. The promise of frugal innovation in terms of value creation must lie in terms of, importantly, the nature of the processes that underly economic value differ significantly from that of social value. The intersection of strategy, innovation, and entrepreneurship typically manifests in which a single firm is the central reference point. The contrasts these binaries present is one of how relationships between variables work as the interaction between its systemic, structural parts and creation of assemblages not inherent in any of the elements. Relatively less attention is paid to the mechanism-based theorizing that is involved. At this vanishing point is the realization that innovation is often what is tangibly commercialized (). The focus of many definitions of frugal innovation has been prioritizing the values of the base of the pyramid, bringing the values of accessibility and affordability into focus. However, accessibility involves addressing the social consequences of inequality that appear as a “wicked problem.” This approach has either understood accessibility in terms of trade-offs between poverty and income inequality. Among the key criticisms of frugal innovation, variously conceptualized, is the inability to provide a suitable mechanism for individuals to create social and economic value. This assessment adopts a multi-level perspective and assumes that ecosystems also draw upon value-creation logic. Thus, the entire project that values creation from business models at the firm and ecosystem levels is closely linked. The sources of value that drive value creation at both these levels.

Notes

¹ Alf Rehn and Anders Örtengren (2023) (eds), "Debating Innovation- Perspectives and Paradoxes of an Idealised Concept", Palgrave Debates in Business and Management, Palgrave MacMillan Publishing, Switzerland. See Introduction.

² Timothy Bloxam Morton (2013), "Hyperobjects: Philosophy and Ecology after the End of the World War", University of Minnesota Press, Minneapolis. The term was used originally to express interest in objects and/or concepts that were so massive and distributed in time and space that it become impossible to understand them specifically as themselves, rendering them only thinkable through their symptoms or local manifestations. Seen thus, they are viscous in nature, in as much as they attach themselves to other objects, material and discursive, even to a point of resistance that makes you evermore stuck to the same.

³ A. Coad, P. Nightingale, J. Stilgoe & A. Vezzani (2021), "The Dark side of innovation", Industry and Innovation, Volume no. 28 (1), pp. 102-112

⁴ *supra*1. See Chapter 3 - Thomas Taro Lennerfors and Kiyoshi Murata, 2023 "Innovation Ethics" at pp. 33- 53

⁵ M. Bourban and J. Rochel (2021), "Synergies in innovation: Lessons learnt from innovation ethics for responsible innovation", Philosophy and Technology, Volume no. 34, Issue no. 2, pp. 373-394.

⁶ H. Fornstedt (2021), "Innovation resistance: Moving beyond dominant framings", Doctoral Thesis, Uppsala University, Sweden.

⁷ *supra*4. See Chapter 3 at pp. 35

⁸ A. Hornborg (2001), "The power of the machine: Global inequalities of economy, technology , and the environment", Lanham, Baltimore, Rowman Altamira

⁹ I van de Poel and L. Royakkers (2011), "Ethics, Technology and engineering: An introduction" John Wiley & Sons, Chichester, United Kingdom.

¹⁰ E. Palm and S.O Hansson (2006), "The case for ethical technology assessment (eTA)", Technological Forecasting and Social Change , Volume no. 73 (5), pp. 543-558.

¹¹ Krzysztof Dembek, Prakash Singh and Vikram Bhakoo (2016), "Literature Review of Shared Value: A Theoretical Concept or a Management Buzzword ?", Journal of Business Ethics, Volume no. 137, pp. 231-267

¹² Porter and Kraemer, 2011 define shared value as "policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates". Alternative accounts conceptualise it in terms of choices. (See, 2009).

¹³ Kazuhiro Asakawa, Alvaro-Cuervo-Cazurra and C. Annique Un (2019), "Frugality-based advantage", Long Range Planning, Volume no. 52, pp. 101879.

¹⁴ Jarkko Levanen, Mokter Hossain, Marleen Wierenga (2022), "Frugal Innovation in the midst of societal and operational pressures", Journal of Cleaner Production, Volume no. 347, pp. 131308.

¹⁵ Chandni Hindocha et al., 2021 , "Defining frugal innovation: a critical review", British Medical Journal of Innovation, Volume no. 7, pp. 647-656

¹⁶ M. Pansera (2018), "Frugal or fair ? The unfulfilled promises of frugal innovation, "Technology Innovation Management Review, Volume no. 8 (4), pp. 6-13.

¹⁷ A. Leliveld and P. Knorrinda (2018), "Introduction: frugal innovation and development research", European Journal of Development Research, Volume no. 30 (1), pp. 1-16

¹⁸ J. Keranen (2017), "Towards a broader value discourse: understanding sustainable and public value potential", Journal of Creating Value, Volume no. 3 (2), pp. 193-199.

¹⁹ G. George et al (2016), "Understanding and tackling societal grand challenges through management research", Academy of Management Journal, Volume no. 59 (6), pp. 1880-1895.

²⁰ Value proposition describes the offering and the kind of customer value the proposed solution provides (Baldasarre et al., 2017).

²¹ Value creation describes how the operations of a firm should be organised to create value (Hossain, 2016).

²² Value capture describes how revenue is generated from such activities (McWilliams and Siegel, 2001).

²³ Resource constraints refer to the lack of critical resources such as materials energy and workforce

²⁴ Affordability constraints refer to social dynamics that prevent large population groups from accessing basic products and services that would improve their living standards and general well-being (Collier, 2007).

²⁵ Institutional constraints refer to socio-cultural and legal aspects that hamper operational business conduct or related innovation activities.

Innovation complementarities in small and micro-enterprises in Johannesburg, South Africa

Godfrey Paradzai Kamutando,
University of Cape Town, South Africa

Fiona Tregenna
University of Johannesburg

Abstract

Innovation is important to firms' productivity, competitiveness, agility, resilience and growth. The success of a firm's innovation strategy depends in part on how it combines and absorbs different innovation activities. This paper analyses complementarity between various innovation activities, for the case of small and micro manufacturing firms in Johannesburg, South Africa. Specifically, we analyse the extent and determinants of complementarity between types of innovation (product and process innovation) and between innovation sources (internal and external innovation). The empirical analysis utilises rich new firm-level survey data which, unlike most firm surveys, includes micro as well as informal enterprises. This contributes to the innovation complementarity literature that is very limited in the African context, and even internationally only sparsely covers small and micro firms, and informal firms. We extend the specifications used in previous studies to take account of the contextual setting. Our results show complementarity between product and process innovations but not between internal and external innovation. The results suggest that the capital intensity of the firm, firm age, ownership, research and development (R&D), main markets and financial constraints are key variables associated with complementarity.

Key Words: innovation complementarities, product innovation, process innovation, research and development (R&D), small and micro-enterprises, South Africa

JEL codes: D22, L60, O14, O30, O32, O33

Acknowledgements:

Funding under the South African Research Chairs Initiative of the Department of Science and Technology and National Research Foundation of South Africa (Grant No. 110691), through the Community of Practice in Innovation and Inclusive Industrialisation under the DST/NRF South African Research Chair in Industrial Development, towards this research is hereby acknowledged.

1. Introduction

The importance of innovation in strengthening firms' productive capabilities, competitiveness, productivity and overall performance is now widely recognised (Dosi et al. 1988; Fagerberg and Godinho, 2005; Gunday et al., 2011; Gebreeyesus and Mohnen, 2013; Guarascio and Pianta 2017). It is therefore critical to understand firms' innovation strategies, particularly of small and micro-enterprises (MSEs) in developing countries, which are seen as important for growth and employment creation (McPherson, 1996; Miravete and Pernías, 2006; Li & Rama, 2015).

Technological innovations include product and process innovations, while sources of innovation can be internal or external to a firm, also referred to as 'make' or 'buy' innovation routes.¹ An established body of literature considers different types of innovation (product and process) or sources of innovation (internal and external) as distinct activities with separate and different effects on firm performance (Fristch & Meschede, 2001; Baldwin & Lin, 2002). An area of growing interest in the literature concerns the possible interrelationships between various firm innovation activities. The integrative theory of innovation argues that different kinds of innovation are interdependent on one another, and that the success of a firm's innovation strategy can be enhanced if a firm implements several forms of innovations simultaneously (Das & Teng, 2003; Guisado-González & Coca Pérez, 2015). In essence, firm innovation types and sources might not function in isolation, but may either complement or substitute each other. For instance, while transaction cost theory regards the choice between sourcing innovation internally or externally as substitutes, recent literature points to the possible complementarity between internal and external innovation (Cockburn & Henderson, 1998; Cassiman & Veugelers, 2006; Schmiedeberg, 2008). Recognising the potential complementarities in firm innovation activities can shed light on the relational phenomena of firm synergies and how these affect firm performance.

What seems critical, particularly for MSEs, is how to integrate innovation activities within a firm's broad innovation capabilities to harness the positive spillovers from each innovation activity. Complementarity between firm innovation strategies may increase the probability of success of these activities (Battisti and Stoneman 2010; Damanpour et al. 2009; Cassiman and Veugelers 2006). Firms that blend innovation activities may therefore outperform firms that only implement one strategy. Establishing complementarity, and identifying what influences the adoption of complementary innovation activities, is therefore important for managing a successful firm innovation strategy.

A growing body of literature has thus started to empirically investigate the notion of innovation complementarities, generating heterogeneous and case-specific results (Cassiman & Veugelers, 2006). However, there is still a paucity of studies devoting attention to understanding the complementarity of innovation types and sources in MSEs specifically, and even less so in developing country contexts. It is thus pertinent to test this empirically in specific contexts.

This paper analyses the extent to which types of innovation (product and process) and sources of innovation (internal and external) are complementary to each other, for the case of South African manufacturing MSEs. Specifically, we ask the following questions: (1) Are innovation strategies complementary? (2) What firm characteristics influence whether a firm undertakes complementary innovation activities?

Adapting the estimation approach of Cassiman and Veugelers (2006), we formally identify complementarity by investigating differences in firm performance outcomes are associated with whether or not firms combine their innovation strategies. We extend the Cassiman and Veugelers (2006) approach by including contextual variables relevant to MSEs (including informal enterprises) in developing countries. The presence of innovation complementarity is tested for using ordered probit and Heckman selection regressions (research question 1 above), while a multinomial logit model is estimated to identify the determinants of complementary innovation activities (research question 2).

We utilise a novel dataset from a firm-level survey of manufacturing MSEs in the City of Johannesburg. Johannesburg is the economic centre of South Africa, accounting for 16% of GDP and 10% of the country's population (City of Johannesburg, 2021). South Africa provides an interesting context to assess innovation complementarity for MSEs. Small, medium and micro-enterprises (SMMEs) contribute about a third of South Africa's GDP and employ around 50–60% of the country's workforce (World Bank & IFC, 2018). South Africa's National Development Plan (NDP) envisages that SMMEs will account for up to 80% of GDP growth and could contribute up to 90% of new employment by

the year 2030. However, South African SMMEs face various obstacles, including lack of access to finance, barriers to entry and difficulties in accessing markets, and poor infrastructures.

Despite the voluminous literature on various aspects of firm innovation, there generally is a lack of studies on innovation complementarities in Africa, and more broadly a scarcity of evidence on this topic for small and especially for micro-enterprises. This is largely due to the paucity of firm-level data that covers these types of enterprises while also including innovation variables in sufficient depth. Furthermore, unlike most datasets and hence the extant literature, our study includes informal enterprises, allowing us to analyse whether formality is associated with innovation complementarity. This is particularly important in light of the importance of the informal economy in Africa and in developing countries more widely, especially among MSEs. We also extend specifications from the extant literature to include variables (such as firm ownership, financial access constraints and informality) that can be especially relevant in this context.

The rest of the paper is structured as follows. Section 2 reviews the theoretical and empirical literature focusing on innovation complementarity. In section 3 we set out the empirical strategy used to identify complementarity. Section 4 gives an overview of the data and provides some descriptive analysis. The empirical results are presented and discussed in section 5, and section 6 concludes.

2. Literature Review

2.1. Theory

The success of a firm's innovation strategy can be influenced by how it absorbs and combines different innovation activities to develop comparative advantage (Mantovani, 2006; Love & Roper, 2009; Hagedoorn & Wang, 2012). Several theoretical perspectives have been developed to hypothesise how combining different innovation strategies can affect firm performance.

First, the resource-based view hypothesises that firm performance is determined by a competitive advantage gained through developing, sustaining and combining firms' heterogeneous resources (Wernerfelt, 1984; Peteraf, 1993; Das & Teng, 2003; Guisado- González & Coca Pérez, 2015). In this theoretical approach, a combination of resources generates synergies such that the combined effect of firm resources or strategies on firm performance is 'greater than the sum of its parts'. This is in line with super modularity theory, which has been widely used to test innovation complementarity (Mohnen & Röller, 2005; Miravete & Pernías, 2006; Bianchini, Pellegrino & Tamagni, 2018). According to this theory, complementarities between various firm innovation strategies are key to enhancing competitive advantage and hence firm performance.

Second, transaction cost theory suggests that firms attempt to minimise uncertainty and transaction costs through risk-sharing. One way in which this can be achieved is through establishing strategic alliances between firms. Transaction cost theory predicts complementarity between internal and external innovation, where bundles of diverse technologies are converted into new products. For example, Oxley and Sampson (2004) posit that rather than opting for either internal or external innovation, adopting both internal and external innovation is an effective firm strategy as this minimises costs by sharing risks.

Third, the 'distinctive view' considers different kinds of innovation as compartmentalised strategies and hypothesises that different kinds of innovation (for instance, product vs. process, or internal vs. external) are determined by different variables and have a different effect on firm performance outcomes (Damanpour et al., 1989; Ackoff, 1999; Fritsch & Meschede, 2001). This theory does not expect complementarity between innovation strategies and instead argues that these strategies take place alternatively, with no interrelationships among them. This approach suggests that different resources need to be provided for different kinds of innovation strategies.

2.2. Empirical literature

Differences in the theoretical formulations have lent themselves to differences in the criteria and methodology used to identify the existence of innovation complementarity in the empirical literature (Aldieri et al, 2021; Arora & Gambardella, 1994; Mohnen & Röller, 2005; Cassiman & Veugelers, 2006). Here, we review empirical literature that has tested complementarity between internal and external innovation (section 2.2.1) and between product and process innovation (section 2.2.2), before reviewing the scant literature on innovation complementarities in the African context (section 2.2.3).

2.2.1. Complementarity between internal and external innovation

A large body of literature explores innovation complementarity between internal and external innovation (Arora & Gambardella, 1990; Cassiman & Veugelers, 2006; Schmiedeberg, 2008; Love & Roper, 2009; Bianchini et al., 2018). Cassiman and Veugelers (2006) use firm-level data for Belgium manufacturing firms and apply the productivity and the adoption regression approaches to test for complementarity between internal and external innovation. They found significant evidence of innovation complementarity between internal and external innovation with respect to firm innovation performance. Furthermore, their analysis revealed that the strength of complementarity between activities is influenced by the extent to which innovation processes depend on R&D. They concluded that success in innovation does not depend only on complementarity, but also on establishing the right business environment.

Similarly, using the direct approach, Schmiedeberg (2008) explicitly analysed complementarity between internal and external R&D, drawing on cross-sectional data for German manufacturing firms. Hagedoorn and Wang (2012), in a case study of 83 pharmaceutical firms, identify complementarity between internal and external innovation where there are high levels of in-house R&D investment, but a substitution relationship if in-house R&D investment is low. Thus, whether internal and external innovation sourcing is complementary is contingent on the level of in-house R&D investment, which shapes firm absorptive capacity.

Arora and Gambardella (1994) find evidence supporting the complementarity hypothesis, suggesting that firm internal R&D orientation is key to driving the observed innovation complementarity between internal and external innovation, as also argued by Hagedoorn and Wang (2012). Other studies that found evidence of complementarity between internal and external innovation include Lokshin et al. (2008) for Dutch firms, and Love and Roper (2009) for German and UK firms.

In contrast, Schmiedeberg (2008) finds no evidence of innovation complementarity between internal and external innovation, refuting the resource-based hypothesis of complementarity. Other studies that have found no evidence of complementarity include those by Laursen and Salter (2006), Vega-Jurado et al. (2009) and Hess and Rothaermel (2011).

2.2.2. Complementarity between product and process innovation

A number of studies have empirically analysed the complementarity between product and process innovation at the firm level. Using panel data for Spanish manufacturing firms, Bianchini et al. (2018) tested the link between firm performance, as measured by sales growth, and the joint adoption of product and process innovation. The key question they addressed was whether performing two joint innovation activities increased sales growth compared to when innovation activities were undertaken separately. Their results show that separately implementing product and process innovation does not significantly affect firm growth, but that growth is enhanced when product and process innovation activities are undertaken jointly. Miravete and Pernías (2006) developed a structural discrete choice model to distinguish between complementarity and correlation induced unobserved heterogeneity, using data for Spain. They found significant evidence suggesting the presence of complementarity between product and process innovation. Berulava and Gogokhia (2016) used micro-level data for several European countries, and also find support for the existence of complementarity between product and process innovation.

Using the 2003 World Bank Investment Climate Survey (ICS) data for manufacturing firms in Brazil, Goedhuys and Veugelers (2012) analysed factors

affecting innovation performance and firm growth. Their findings provide evidence that innovative performance – in particular the joint adoption of both product and process innovation – drives firm growth. Other studies that support the hypothesis of product and process innovation complementarity, finding that product-process innovation complementarity aids firm performance more than innovation activities undertaken in isolation, include Kraft (1990), Reichstein and Salter (2006) for UK firms, and Ballot et al. (2011) for the UK and France. In contrast, Martin and Nguyen-Thi (2015) analysed whether firm productivity is enhanced through innovation complementarity and found no significant association between product and process innovation in affecting labour productivity in firms in Luxembourg.

2.2.3. Innovation complementarity literature in Africa

The literature on innovation complementarity is still very scarce in the context of Africa. An important constraint here is the lack of suitable firm-level data with relevant variables. In one of the few available studies, Egbetokun et al. (2016) analysed complementarity between internal and external innovation using survey data for Kenya and Nigeria. Drawing on Cassiman and Veugelers' (2006) methodology, they found evidence consistent with the hypothesis of innovation complementarity between internal and external innovation in the case of Kenya, but not for Nigeria. Unlike most studies in the literature that use firm productivity as an indicator of firm innovation performance, they used a measure of the percentage of sales from innovation activities. Their study points to the importance of differences in the context of country economies in shaping firm performance through complementing innovation activities. In a closely related study, Okumu, Bbaale and Guloba (2019) estimated the link between employment growth and innovation using the World Bank Enterprise Survey (WBES) data for 27 African countries. They also tested whether complementarity between product and process innovation was associated with employment growth. Their results show evidence in support of the complementarity hypothesis.

Our paper differs from these other studies on African countries in several ways. First, our study focuses on MSEs in the manufacturing sector, also including informal enterprises. Second, utilising the richness of our new dataset that includes a range of innovation variables as well as variables on other firm characteristics, we are able to adapt and extend our specifications to include relevant considerations such as informality, firm ownership and financial access constraints. These factors are of particular relevance in the African context, especially when considering formal and informal MSEs.

While the empirical literature provides some important insights, it is clear that the subject of innovation complementarity is far from settled. As with the diversity in theoretical perspectives and predictions, the results from the empirical evidence on whether firm innovation strategies are complementary

are mixed and inconclusive. It seems that differences in methodology and economic contexts account for the differences in findings observed across the existing literature. This context-specificity of findings underscores the importance of empirical analysis in African and other developing country contexts.

As noted, most of the empirical literature on innovation complementarities focuses on developed countries (Schmiedeberg, 2008; Love & Roper, 2009; Hagedoorn & Wang, 2012). Generally, there is a lack of studies on innovation complementarities in Africa, due in part to the paucity of suitable firm-level data. Yet the subject of innovation is particularly important for developing countries that are far from catching up to the productivity levels of developed economies.

Further, there is very little coverage of MSEs, despite these firms being recognised as important for growth, entrepreneurship and employment creation in developing countries. This research thus helps to fill a gap in the literature by using a developing country in Africa and focusing on MSEs, including informal enterprises, and by extending previous econometric specifications to take account of these contextual specificities.

3. Estimation strategy

3.1. Identifying the existence of complementarity

To empirically identify whether innovation complementarity exists, we adopted the direct or productivity approach followed by Cassiman and Veugelers (2006) and Schmiedeberg (2008). The advantage of this approach is that it allows us to test for complementarity directly, rather than just relying on conditional correlations between residuals of the reduced form estimations, as is the case with the indirect or adoption approach. The productivity approach is implemented by regressing firm performance measures on indicators of firm innovation activities. In this study, we test, first, complementarity between product and process innovation and, second, complementarity between internal and external innovation.

We first created an indicator variable that shows whether a firm adopted either process or product innovation, or both. Similarly, we created another indicator variable indicating whether a firm adopted either internal or external innovation or both. Our sample excludes firms that did not undertake any of these innovation activities. The productivity approach was implemented by separately estimating the following specifications:

$$Y_i = \alpha_0 + \beta_1 \text{Prod\_innoi} + \beta_2 \text{Proc\_innoi} + \delta_0 (\text{Prod\_innoi} \times \text{Proc\_innoi}) + \rho_0 X_i + u_i \quad (1)$$

$$Y_i = \alpha_1 + \beta_3 \text{Int\_innoi} + \beta_4 \text{Ext\_innoi} + \delta_1 (\text{Int\_innoi} \times \text{Ext\_innoi}) + \rho_1 X_i + \varepsilon_i, \quad (2)$$

where Y_i is firm performance (measured as change in revenue), Prod_innoi is a dummy for product innovation only, Proc_innoi is a dummy for process innovation only, Int_innoi is a dummy for internal innovation only, and Ext_innoi is a dummy for external innovation only. X_i is a vector of controls that affect firm performance. All variables are discussed in more detail in section 4.2.

Complementarity is identified by the coefficient of the interaction terms, δ_0 and δ_1 , in equations 1 and 2 for product/process and external/internal innovation, respectively. Complementarity is indicated if the coefficient of an interaction term is positive and statistically significant. A negative and significant coefficient suggests that the respective innovation activities are substitutes. Because the dependent variable is an ordered categorical variable (see section 4.2 for more details), we estimated equations 1 and 2 using the ordered probit model.

Because we restricted our sample size to only innovative firms when using the productivity approach, it was possible that we could encounter a dummy variable trap problem. This is because our sample does not contain firms that adopt none of product, process, internal or external innovations. One way to solve this, which we followed, is to drop one dummy variable when running the estimations. Another problem when testing for complementarity is possible selection bias. This problem arises because we only included innovative firms in the estimations, but these firms may differ from non-innovative firms in terms of performance. To account for possible selection bias, we used the conventional method in the literature, the Heckman two-stage selection model.²

3.2. Determinants of complementary innovation strategies

After identifying complementarity (as set out in 3.1 above), next we analyse drivers of innovation activities and identify variables that could influence the joint adoption of innovation activities, and thus complementarity. To achieve this, we performed the multinomial logit regression specified below (based on Cassiman and Veugelers 2006).

$$\text{Pr}(V_i = j) = \frac{\exp(\beta_j z_i)}{\sum_{m=1}^J \exp(\beta_m z_i)} \quad (3)$$

$j \in \text{internal only (1); external only (2); joint internal and external (3), alternatively}$

$j \in \text{product only (1); process only (2); joint product and process (3),}$

where z_i is a vector of characteristics of firm i .

The multinomial logit model identifies determinants of exclusive combinations of the various innovation activities, specifically of the joint adoption of

innovation activities. That is, variables that are statistically significant in the multinomial logit results for joint internal and external or joint product and process, but that are not significant for innovation strategies that involve only one innovation type (product or process but not both) or innovation source (external or internal but not both). These determinants can help in explaining the observed correlation between, for example, internal and external innovation, or product and process innovation, and can thus be identified as contextual variables influencing complementarity

4. Data and descriptive analysis

4.1. Data

We exploit a novel cross-sectional firm-level dataset covering manufacturing MSEs, that was collected in Johannesburg, South Africa in 2019. Part of this richness of this dataset lies in the inclusion of (1) micro-enterprises and (2) informal enterprises, that are generally excluded from firm-level surveys.³ This is the first survey in South Africa that covers these categories of enterprises and that also collects detailed information on innovation, and there are few similar surveys in other developing countries (especially lacking in Africa), enabling empirical analysis of firm-level innovation that was not previously possible.

The survey was undertaken under the DSI/NRF South African Research Chair in Industrial Development, through the project 'Community of Practice in Innovation and Inclusive Industrialisation'.⁴ The survey followed the Oslo Manual in measuring and investigating firm innovation (OECD, 2018). While focused on innovation, the survey collected relevant data on a broader set of firm characteristics and behaviour. The survey included 74 questions, and the firm interviews were conducted by a professional survey company over the period June-August 2019.

The survey collected detailed data on MSEs, classified as those with 50 or fewer workers (based on official definitions of MSEs)⁵. The survey covered all enumerator areas (EAs) that were designated for commercial or industrial use within the urban development zone (UDZ)⁶ of the City of Johannesburg; any additional EAs that were classified as industrial in the 2011 Census; and adjacent residential EAs where manufacturing activities had extended across EA boundaries. In the selected EAs, a census was conducted of all businesses operating in each EA to construct a sample frame, from which manufacturing businesses could then be selected.⁷ The data is representative of manufacturing MSEs in Johannesburg.

Of the 711 firms in the full sample, 54% were found to have undertaken some form of innovation.⁸ As discussed, the sample is restricted to innovative firms for the empirical analysis. Our final sample thus constitutes 382 firms.

4.2. Variables

Here, we set out (1) how we measure innovation and specifically innovation complementarity;

(2) our dependent variable measuring firm performance; and (3) our control variables. Variables are summarised in Table 1 below and discussed further thereafter.

Table 1: Description of variables

Variable	Variable type	Definition/construction
<i>Dependent variable</i>		
Change in revenue	Ordered categorical	Change in revenue from the previous financial year. 1 if revenue decreased, 2 if there was no change, and 3 if revenue increased
<i>Explanatory variables</i>		
Product only	Dummy	1 if the firm engaged in product innovation but not process innovation, and 0 otherwise
Process only	Dummy	1 if the firm engaged in process innovation but not product innovation, and 0 otherwise
Product and process	Dummy	1 if the firm engaged in both product and process innovation, and 0 otherwise.
Internal only	Dummy	1 if the firm engaged in internal but not external innovation, and 0 otherwise
External only	Dummy	1 if the firm engaged in external but not internal innovation, and 0 otherwise
Internal and external	Dummy	1 if the firm engaged in both internal and external innovation, and 0 otherwise
Firm size	Continuous	Total number of workers a firm employs (log)
Firm age	Categorical	Age of the firm, categorised as 0-5 years, 6-15 years, 16-30 years, and >30 years.
Capital intensity	Continuous	Ratio of capital stock to labour (log)
Formality	Dummy	1 if the firm is registered (formal), and 0 if it is unregistered (informal)
Financial constraints	Dummy	1 if the firm reports that financial factors limit its growth, and 0 otherwise
Ownership	Dummy	1 if a firm is owned by a South African citizen, and 0 otherwise
R&D	Dummy	1 if the firm engaged in R&D activities during the last financial year, and 0 otherwise
Market	Categorical	Indicates the main market for the firm: 1 if individuals, 2 if small businesses, 3 if medium-sized businesses and 4 if large businesses
Industry	Categorical	Industry is clustered into four groups according to the NACE-Rev.1 classification ⁹ (1) Low-tech;

(2) Medium low-tech; (3) Medium high-tech;
and (4) High-tech.

Innovation complementarity

We investigate innovation complementarity along two separate dimensions of innovation activities: complementary between different types of innovation (referring to product and process innovation), and complementary between different sources of innovation (referring to internal and external innovation).

Firstly, in terms of innovation types, product innovation involves creating new products or services that differ significantly from existing products and also involves upgrading or improving the existing version of the products to enhance performance or lower costs. Process innovation involves the adoption of new or significantly improved production techniques. This may include changes in methods of manufacturing, delivery or distribution, equipment or use of new knowledge, among others, with the intention to produce or increase production of new or existing products. Firms were asked in the survey whether they had done innovation by introducing any of the following: entirely new products; significantly improved products; introduced entirely new services; significantly improved services; introduced entirely new processes; significantly improved processes; or none of these. From the responses, we generated three binary variables indicating whether (among our sample of innovative firms): (1) a firm only undertook product innovation, (2) a firm only undertook process innovation, and (3) a firm undertook both product and process innovation. We are interested in how these responses correlate with each other.

Secondly, with regard to innovation sources, we consider complementarity between internal and external sources of innovation. Internal innovation refers to a firm using in-house R&D to develop its technology, while external innovation involves acquiring technology from outside the firm boundaries (OECD, 2018). This may involve 'buying' technology from other organisations or subcontracting. In the survey, firms were asked by whom the firm innovation improvements were developed. From the firm responses,¹⁰ we created three binary variables indicating whether: (1) a firm was involved in only internal innovation, (2) a firm was involved in only external innovation, and (3) a firm was involved in both internal and external innovation.

Dependent variable: firm performance

Based on the production approach, we use change in revenue as the dependent variable measuring firm performance¹¹Change in revenue is an ordered variable, coded 1 if revenue decreased, 2 if there was no change and 3 if the revenue increased.¹²

Control variables

Drawing on the literature, extending this with reference to the local context, and taking account of data availability, we included relevant control variables. Including a measure of formality allows us to assess the difference in innovation strategies between formal and informal sector firms. We include ownership, to account for differences between firms owned by South Africans and those owned by citizens of other countries. Financial access constraints can affect firm innovation strategies, and we control for this by including a measure of financial constraints. We also include a variable indicating whether a firm is engaged in R&D. R&D plays a critical role in firm innovation strategies, and we expect that firms that engage in R&D could be more complementary in their innovation strategies. Furthermore, we control for the firm's industry, to account for heterogeneity across the industries of manufacturing. We classify industries according to their technology intensity, drawing on the UN-DESA (2008) ranking of industries, as low-tech; medium low-tech; medium high-tech and high-tech firms. Firms in relatively high-tech industries are typically more likely to adopt complementary innovation strategies.

4.3. Descriptive statistics

Table 2 presents the descriptive statistics. With regard to our dependent variable, change in revenue, the results presented show that 41% of firms experienced a decrease in sales, while 32% of firms had an increase in sales, relative to the previous financial year. Looking at innovation variables, Table 2 suggests that 79% of firms engage only in product innovation, 9% engage only in process innovation and 12% engage in both product and process innovation. 43% of firms use only external sources of innovation, 39% use only internal sources, while 18% use both internal and external sources.

The average firm size is about eight workers, while 40% of firms are up to five years old. 42% of the firms in the sample are formal enterprises. Financial access constraints seem to be a major obstacle, as 67% of firms reported being constrained. Most firms (67%) are owned by South African citizens. 21% of firms reported engaging in R&D activities. The majority of firms (72%) report that individuals are the most important market for their products. Most of the firms are in low-technology industries (77%).

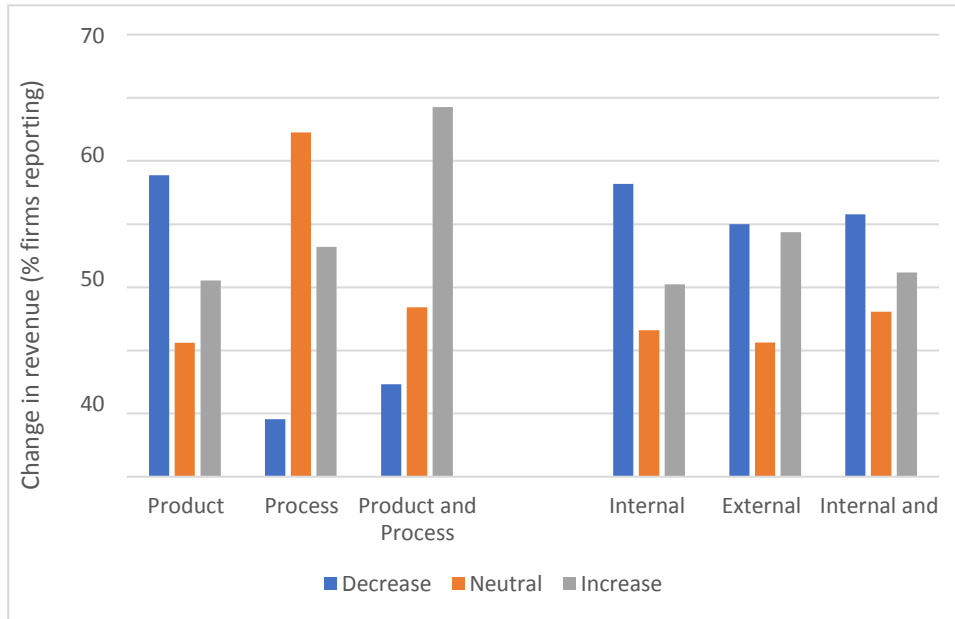
Table 2: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Change in revenue (dependent variable)					
1. Decrease	351	0.41	0.49	0	1
2. Neutral	351	0.26	0.44	0	1
3. Increase	351	0.32	0.47	0	1

Innovation variables					
Product	351	0.79	0.36	0	1
Process	351	0.09	0.16	0	1
Product and process	351	0.12	0.33	0	1
Internal	351	0.39	0.49	0	1
External	351	0.43	0.50	0	1
Internal and external	351	0.18	0.38	0	1
Firm size	351	7.72	8.61	1	45
Firm age					
0-5	351	0.40	0.49	0	1
6-15	351	0.34	0.48	0	1
16-30	351	0.17	0.38	0	1
>30	351	0.08	0.28	0	1
Capital (R'000)	351	1 979.38	9 879	0	80 000
Formality	351	0.42	0.49	0	1
Financial constraints	351	0.68	0.47	0	1
Ownership	351	0.67	0.47	0	1
R&D	351	0.21	0.41	0	1
Market					
1. Individual bus.	351	0.72	0.45	0	1
2. Small bus.	351	0.15	0.36	0	1
3. Medium bus.	351	0.07	0.26	0	1
4. Large bus.	351	0.05	0.21	0	1
Industry					
1. Low tech	351	0.76	0.43	0	1
2. Med-low tech	351	0.18	.38	0	1
3. Med-high tech	351	0.06	0.24	0	1

Figure 1 presents descriptive patterns of firm innovation strategies (product/process and internal/external) and firm performance (measured as change in revenue from the previous financial year). Looking at product and process innovation, Figure 1 suggests that a higher proportion of firms that engage in both product and process innovation report an increase in revenue than firms that engage in only product or process innovation. However, it seems there is no obvious pattern between change in revenue and engaging in both internal and external innovation. This is shown by the fact that the proportion of firms reporting an increase in sales is not different for firms that engage in both internal and external innovation and those that only engage in internal or external innovation.

Figure 1. Relationship between innovation activities and firm performance



4.4. Correlation of innovation activities

In Table 3, we descriptively explore innovation complementarity using pairwise correlations between innovation activities. Positive significant pairwise correlations suggest innovation complementarity, while negative correlations suggest a substitution relationship. Column 1 presents the non-exclusive frequencies of innovation activities. It shows that an overwhelming majority of firms (96.9% of our sample of innovating firms) engaged in product innovation, while 14.7% have engaged in process innovation. In terms of innovation sources, the majority of firms (61.3%) acquire innovation externally, while a slightly lower proportion (56.6%) undertake innovation internally. Table 3 also presents unconditional and conditional correlations between firstly product and process innovation, and secondly internal and external innovation. The conditional correlations are derived from the residuals of a bivariate probit model.

The descriptive results in column 2 of Table 3 indicate a low but positive and significant correlation between product and process innovation, which could point to complementarity between these types of innovation. The correlation, however, becomes smaller and insignificant with the inclusion of control variables, as shown by the conditional correlation in column 3. Further, column 2 shows a negative and significant correlation between internal and external innovation, suggesting a possible substitution relationship between these innovation sources. The magnitude reduction and insignificance of the conditional correlation in column 3 also suggests that we may have accounted for possible variables that drive the relationship between internal and external innovation. The descriptive results in Table 3 are in line with several other

studies in the literature (Cassiman & Veugelers, 2006; Schmiedeberg, 2008; Love & Roper, 2009; Hagedoorn & Wang, 2012)

Table 3. Correlations between innovation strategies

Innovation strategies	Frequency	Unconditional correlations	Conditional correlations
	1	2	3
Product	342(95.2%)		
Process	56(14.7%)	0.177***	0.136
Internal	201 (57.3%)		-0.060
External	213 (60.7%)		

5. Empirical results

5.1. Identifying complementarity

The correlations presented above provide only a preliminary investigation towards identifying and testing for complementarity and are not sufficient. To formally analyse complementarity, we first assess how combinations of product and process types of innovation, and separately of internal and external innovation sources, affect firm performance. This is estimated using the productivity approach specified in equations 1 and 2 and estimated through ordered probit and Heckman selection regressions.

Table 4 presents the main regression results for complementarity between product and process innovation, with our key variable of interest being the interaction between product and process innovation (product and process). Similarly, Table 5 presents the main results for internal and external innovation, where our key variable of interest is the interaction between internal and external innovation (internal and external). We dropped the dummies for product innovation and internal innovation in tables 4 and 5 respectively, due to the dummy trap problem noted earlier.

Table 4. Complementarity between product and process innovation

	(1)	(2)	(3)	(4)	(5)	(6)
Ordered probit marginal effect						Heckman
selection ME						
VARIABLES	Decrease	Neutral	Increase	Decrease	Neutral	Increase
Process	-0.158* (0.094)	-0.009 (0.019)	0.167 (0.112)	-0.190 (0.134)	-0.006 (0.028)	0.196 (0.162)
Product and process	-0.256*** (0.060)	-0.027 (0.021)	0.283*** (0.078)	-0.246*** (0.069)	-0.010 (0.018)	0.255*** (0.084)

Firm size (log)	-0.108 (0.081)	0.008 (0.008)	0.100 (0.075)	-0.094 (0.082)	0.011 (0.010)	0.083 (0.073)
Firm size squared (log)	0.028 (0.024)	-0.002 (0.002)	-0.026 (0.022)	0.026 (0.024)	-0.003 (0.003)	-0.023 (0.021)
Capital intensity (log)	-0.003 (0.006)	0.000 (0.000)	0.003 (0.005)	-0.004 (0.006)	0.000 (0.001)	0.003 (0.005)
Firm age						
2. 6-15	0.082 (0.061)	-0.002 (0.004)	-0.080 (0.059)	0.080 (0.060)	-0.006 (0.006)	-0.074 (0.055)
3. 16-30	0.164** (0.072)	-0.014 (0.012)	-0.150** (0.064)	0.147* (0.075)	-0.017 (0.014)	-0.130** (0.064)
4. >30	0.215** (0.101)	-0.026 (0.025)	-0.189** (0.080)	0.212** (0.102)	-0.034 (0.027)	-0.178** (0.078)
Formality	0.002 (0.057)	-0.000 (0.004)	-0.002 (0.052)	0.020 (0.057)	-0.002 (0.007)	-0.017 (0.050)
Financial constraints	-0.017 (0.057)	0.001 (0.005)	0.015 (0.052)	-0.015 (0.056)	0.002 (0.007)	0.014 (0.049)
Ownership	-0.091 (0.059)	0.009 (0.008)	0.081 (0.051)	-0.094** (0.043)	0.013 (0.010)	0.081** (0.039)
R&D	-0.106 (0.068)	0.003 (0.005)	0.103 (0.070)	-0.129** (0.064)	0.007 (0.005)	0.121* (0.064)
Market						
2. Small bus.	-0.039 (0.075)	0.001 (0.002)	0.038 (0.074)	-0.022 (0.071)	0.002 (0.005)	0.020 (0.066)
3. Medium bus.	0.217** (0.109)	-0.048 (0.037)	-0.169** (0.074)	0.217** (0.103)	-0.052 (0.036)	-0.166** (0.069)
4. Large bus.	-0.097 (0.112)	-0.001 (0.011)	0.099 (0.122)	-0.034 (0.115)	0.002 (0.006)	0.032 (0.110)
Industry						
2. Med-low tech	0.042 (0.068)	-0.004 (0.007)	-0.039 (0.061)	0.042 (0.068)	-0.005 (0.010)	-0.037 (0.058)
3. High tech	0.135 (0.114)	-0.021 (0.027)	-0.115 (0.088)	0.116 (0.114)	-0.020 (0.027)	-0.096 (0.087)
Observations	351	351	351	351	351	351

Note: The dependent variable is change in revenue, which is an ordered categorical variable (1=decrease; 2=neutral; 3=increase)

Table 5. Complementarity between internal and external innovation

	(1)	(2)	(3)	(4)	(5)	(6)
Ordered probit marginal effect					Heckman	
selection ME						
VARIABLES	Decrease	Neutral	Increase	Decrease	Neutral	Increase
External	0.036 (0.034)	0.014 (0.013)	-0.051 (0.046)	-0.066 (0.056)	0.002 (0.003)	0.064 (0.055)
Internal and external	0.043 (0.042)	0.012 (0.009)	-0.055 (0.049)	-0.002 (0.071)	0.000 (0.003)	0.002 (0.068)
Firm size (log)	0.124*** (0.044)	0.053** (0.022)	-0.177*** (0.058)	-0.092 (0.080)	0.004 (0.005)	0.088 (0.077)
Firm size squared (log)	-0.026* (0.014)	-0.011 (0.007)	0.037* (0.020)	0.017 (0.024)	-0.001 (0.001)	-0.016 (0.023)
Capital intensity (log)	-0.001 (0.004)	-0.000 (0.002)	0.001 (0.005)	-0.005 (0.006)	0.000 (0.000)	0.004 (0.006)
Firm age						
2. 6-15	0.015 (0.033)	0.005 (0.012)	-0.020 (0.045)	0.117** (0.057)	0.001 (0.006)	-0.118** (0.058)
3. 16-30	0.051 (0.045)	0.010 (0.010)	-0.060 (0.050)	0.197*** (0.072)	-0.010 (0.013)	-0.188*** (0.065)
4. >30	-0.096*** (0.034)	-0.141 (0.087)	0.237** (0.116)	0.208** (0.100)	-0.012 (0.020)	-0.196** (0.085)
Formality	-0.019 (0.029)	-0.008 (0.014)	0.027 (0.043)	-0.002 (0.055)	0.000 (0.002)	0.001 (0.053)
Financial constraints	0.071** (0.029)	0.041* (0.022)	-0.112** (0.048)	-0.015 (0.055)	0.001 (0.003)	0.014 (0.052)
Ownership	-0.003 (0.030)	-0.001 (0.012)	0.004 (0.042)	-0.080 (0.059)	0.005 (0.006)	0.076 (0.054)
R&D	0.008 (0.039)	0.003 (0.014)	-0.011 (0.053)	-0.103 (0.063)	-0.001 (0.005)	0.104 (0.066)
Market						
2. Small bus.	-0.091** (0.036)	-0.051 (0.038)	0.142** (0.071)	-0.065 (0.066)	-0.001 (0.004)	0.065 (0.069)
3. Medium bus.	-0.137*** (0.033)	-0.153* (0.084)	0.289*** (0.111)	0.202* (0.105)	-0.036 (0.031)	-0.165** (0.076)
4. Large bus.	-0.128*** (0.042)	-0.125 (0.102)	0.253* (0.140)	-0.121 (0.102)	-0.007 (0.017)	0.129 (0.118)
Industry						
2. Med-low tech	-0.044 (0.036)	-0.025 (0.029)	0.069 (0.064)	0.021 (0.067)	-0.001 (0.004)	-0.020 (0.064)
3. High tech	-0.041 (0.036)	-0.023 (0.029)	0.064 (0.064)	0.080 (0.067)	-0.007 (0.004)	-0.073 (0.064)

	(0.060)	(0.049)	(0.109)	(0.111)	(0.015)	(0.096)
Observations	351	351	351	351	351	351

Note: The dependent variable is change in revenue, which is an ordered categorical variable (1=decrease; 2=neutral; 3=increase)

Considering the coefficients on the interaction product and process in Table 4, we observe negative and significant marginal effects on the probability of a firm having a decrease in revenue (column 1) and positive and significant marginal effects on the probability of a firm having an increase in revenue (column 3). Both these sets of results in Table 4 suggest that undertaking both product and process innovation is positively associated with firm performance outcomes, compared to adopting only product innovation. These results support our hypothesis that complementarity in types of innovation (product and process) is associated with enhanced firm performance. To account of possible selection bias, columns 4 to 6 present the results of the Heckman selection model. These results corroborate our findings in columns 1 to 3: even after correcting for the selection of firms, the results indicate complementarity in types of innovation.

Looking at the marginal effects of the control variables in Table 4, firm age, ownership, R&D and market are statistically significant. For firm age categories 3 and 4, the marginal effects are positive and statistically significant in columns 1 and 4 and negative and significant in columns 3 and 6, indicating that older firms have an association with poorer performance outcomes. The results in column 4 and column 6 respectively indicate negative and positive marginal effects on ownership, indicating that domestically owned firms have less likelihood of reporting a decline in revenue than foreign-owned firms. The negative marginal effects of R&D in column 4 and positive results in column 6 both suggest a positive association between engaging in R&D and firm performance outcomes.

Turning to the complementarity between internal and external innovation, the results in Table 5 show the marginal effects for internal and external to be statistically insignificant across all columns. This suggests that there is no evidence of complementarity (nor of a significant substitution relationship) between internal and external sources of innovation. These results are in line with other studies in the literature that found no complementarity between internal and external innovation (Laurson & Salter, 2006; Schmiedeberg, 2008; Vega-Jurado et al., 2009; Hess & Rothaermel, 2011). It is nevertheless possible that these innovation sources are utilised in a complementary manner in some firms, and as substitutes in other firms. The results on control variables are broadly similar to Table 4.

Our results, therefore, provide evidence that suggests the existence of innovation complementarity between innovation types (product and process innovation), but no evidence of complementarity between internal and external innovation sources.

5.2. Determinants of complementary innovation strategies

Thus far, we have identified the existence of complementarity between product and process types of innovation, but not between internal and external innovation sources. Next, we identify possible variables that might be associated with different choices of innovation strategies: separate or combined types of innovation (product, process) and sources of innovation (internal, external).

Table 6 presents the results of the multinomial logit model specified in equation 3. Columns 1 and 2 provide the results for product and process innovation, while columns 3 and 4 provide the results for internal and external innovation. For the adoption of joint product and process innovation (column 2), the statistically significant variables are capital intensity, firm age, financial constraints, ownership, R&D and market. The positive coefficient of the variable capital intensity suggests that higher capital intensity is associated with a higher likelihood of adopting both product and process innovations, an association that does not hold for the likelihood of only adopting product innovation. Capital intensity can be associated with the capital stock and investment flows enabling joint innovation activities through more extensive and sophisticated equipment.

Regarding firm age, the negative coefficients indicate that older firms are less likely to simultaneously adopt product and process innovations compared to young firms (those aged between 0 and five years). This implies that young firms have a higher propensity for adopting complementary innovation strategies. As suggested in the literature, in a drive to increase firm performance, young firms typically undertake riskier innovation activities that may lead to higher productivity if successful (Schneider & Veugelers, 2010; Coad, Segarra & Teruel, 2016). Furthermore, young firms, as entrants, commonly invest more in innovation activities than incumbent firms in order to enter new markets (Cucculelli, 2018), suggesting that older firms may be less likely to undertake joint innovation activities than younger firms.

Considering financial constraints, the results in column 2 show a negative and weakly significant coefficient, implying that financially constrained firms have a lower probability of adopting product and process innovation than only adopting product innovation. Thus, financial constraints have a negative effect on innovation complementarity, which is intuitive. Further, the positive and significant coefficient of ownership in column 2 indicates that domestically owned firms have a higher likelihood of engaging in both product and process innovation.

The results in column 2 also show a positive association between firms that undertake R&D spending and the probability of combining product and process innovation. Such results imply that engaging in R&D activities is

important for engaging in complementary innovation strategies. Considering the variable market, the results indicate that firms that serve small businesses as their key market are more likely to adopt joint product and process innovation than firms that mainly sell to individuals.

Although the formality variable has the expected sign, it is statistically insignificant. This, therefore, implies that innovation strategies are not different in formal and informal firms. This may be related to the fact that our sample is of MSEs specifically, a segment for which characteristics, operating activities and the environment are similar for both registered and unregistered enterprises.

Turning to the results for internal vs. external innovation in columns 3 and 4, although our contextual variables have expected signs, they are largely insignificant in explaining firms' adoption of both internal and external innovation. This is not surprising, given that we did not find evidence of complementarity between internal and external innovation in Table 5. We thus do not observe the heterogeneity in drivers of innovation strategies when it comes to innovation sources, that is evident in terms of types of innovation.

Table 6. Determinants of innovation strategies: Multinomial logit model

	(1)	(2)	(3)	(4)
Product and process	Internal and external			
VARIABLES	Process only	Both product and process	External only	Both internal and external
Firm size (log)	2.810* (1.653)	0.831 (0.865)	-0.135 (0.400)	0.058 (0.502)
Firm size squared (log)	-0.562 (0.404)	-0.091 (0.214)	-0.094 (0.125)	-0.041 (0.136)
Capital intensity (log)	0.008 (0.063)	0.126** (0.052)	-0.033 (0.030)	0.010 (0.035)
Firm age				
2. 6-15	-1.018 (1.166)	-0.828* (0.424)	-0.354 (0.297)	-0.263 (0.372)
3. 16-30	-0.905 (1.041)	-1.341* (0.706)	-0.267 (0.365)	0.140 (0.441)
4. > 30	-0.296 (1.031)	-0.283 (0.611)	-0.253 (0.539)	0.049 (0.603)
Formality	-0.336 (0.768)	0.077 (0.408)	0.362 (0.273)	0.121 (0.351)
Financial constraints	-0.516 (0.913)	-0.650* (0.376)	-0.032 (0.280)	-0.385 (0.328)

Ownership	0.411 (0.260)	0.149** (0.076)	-0.120 (0.280)	0.402 (0.360)
R&D	0.865 (0.666)	0.756* (0.427)	-0.464 (0.337)	0.061 (0.374)
Market				
2. Small bus.	2.176 (1.419)	0.962** (0.465)	0.072 (0.351)	-0.420 (0.452)
3. Medium bus.	2.914** (1.245)	0.369 (0.554)	-0.435 (0.569)	-0.822 (0.642)
4. Large bus.	3.770*** (1.287)	0.871 (0.707)	0.424 (0.646)	-13.950*** (0.467)
Industry				
2. Med-low tech	-0.216 (1.349)	0.651 (0.439)	-0.506 (0.328)	-0.254 (0.426)
3. High tech	2.390** (0.943)	0.920 (0.671)	-0.920 (0.611)	-0.568 (0.706)
Constant	-7.945*** (1.928)	-4.072*** (0.921)	0.977** (0.463)	-0.370 (0.590)
Observations	351	351	351	351

Notes: The base category for columns 1 and 2 is product innovation, while the base category in columns 3 and 4 is internal innovation. Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

6. Conclusion

Innovation complementarity can be important to the success and impact of firm innovation strategies, including on firm performance. We explore this empirically using novel survey data covering manufacturing MSEs in Johannesburg, South Africa. This data and setting contribute to the literature by providing evidence in an African context, and including micro and informal firms that are generally excluded from similar surveys and hence from the extant literature. We extended specifications used in the literature to take account of factors that could be particularly relevant in this context.

First, we used the productivity approach to formally identify the presence of innovation complementarity. We achieved this by regressing firm performance (measured as change in revenue) on the interaction terms between product and process innovation, as well as internal and external innovation (along with covariates). The consistency in the central findings when using ordered probit and Heckman selection regressions, helps to corroborate the robustness of our results. We find a positive and significant association between combined product and process innovation and change in revenue (relative to either product or process innovation being undertaken separately), suggesting complementary between these types of innovation. However, we did not find evidence of complementarity between internal and external innovation.

We then used a multinomial logit model to identify variables that may drive a firm's decision to adopt joint innovation activities. The results suggest that capital intensity, firm age, R&D, financial constraints and main markets are key variables associated with the joint adoption of product and process innovation. However, these contextual variables are generally insignificant in explaining the joint adoption of internal and external innovation. The management of innovation activities based on understanding the key variables or characteristics is essential in achieving and implementing successful innovation strategies.

These results have relevance for fostering innovation as well as enhancing the impact of innovation on firm performance. Part of this relevance lies in the empirical evidence for MSEs specifically (including informal enterprises) and the African context. For firms, the finding of strong complementarity between product and process innovation points to the importance of undertaking both types of innovation (where feasible), in order to maximise the success of innovation in improving enterprise performance. For policymakers, this finding suggests that incentive and support systems intended to foster firm-level innovation, could give special attention to encouraging both types of innovation being undertaken jointly, rather than regarding these as alternatives. The results on the determinants of complementary innovation strategies, provide policy-relevant evidence as to the key factors that can influence firms jointly adopting product and process innovation.

While our study makes an important contribution to the literature on innovation complementarity, this research agenda could be advanced by searching for other contextual variables that affect complementarity. The effects of innovation on firm performance could furthermore vary over time, for which the use of panel data would be advantageous to investigate the lagging effects of innovation. Future research could also use direct measures of innovation performance (such as the proportion of sales from innovation or the effects of innovation on employment) and other measures of firm performance, that were not available in our dataset.

References

- Ackoff, R.L. 1999. *Re-Creating the Corporation: A Design of Organizations for the 21st Century*. Cary: Oxford University Press.
- Aldieri, L., Barra, C., Vinci, C.P. and Zotti, R. 2021. The joint impact of different types of innovation on firm's productivity: evidence from Italy. *Economics of Innovation and New Technology*. 30(2):151-182.
- Arora, A. & Gambardella, A. 1990. Complementarity and external linkages: the strategies of the large firms in biotechnology. *The Journal of Industrial Economics*. 38(4):361-379.
- Arora, A. & Gambardella, A. 1994. Evaluating technological information and utilizing it: Scientific knowledge, technological capability, and external linkages in biotechnology. *Journal of Economic Behavior & Organization*. 24(1):91-114.
- Baldwin, J. & Lin, Z. 2002. Impediments to advanced technology adoption for Canadian manufacturers. *Research Policy*. 31(1):1-18.
- Ballot, G., Fakhfakh, F., Galia, F. & Salter, A. 2011. The Fateful Triangle Complementarities between product, process and organizational innovation in the UK and France. TEPP - Institute for Labor Studies and Public Policies Working Paper No. 2011-5.
- Battisti, G. & Stoneman, P. 2010. How innovative are UK firms? Evidence from the fourth UK community innovation survey on synergies between technological and organizational innovations. *British Journal of Management*. 21(1):187-206.
- Berulava, G. & Gogokhia, T. 2016. Studying complementarities between modes of innovation strategies in transition economies. MPRA Paper No. 71277
- Bianchini, S., Pellegrino, G. & Tamagni, F. 2018. Innovation complementarities and firm growth. *Industrial and Corporate Change*. 27(4):657-676.
- Cassiman, B. & Veugelers, R. 2006. In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science*. 52(1):68-82.
- City of Johannesburg 2021. City of Johannesburg Integrated Development Plan 2021-26. Available at:https://www.joburg.org.za/documents_/Documents/2021-2016%20Final%20IDP/202126%20FINAL%20IDP%2021May%202021.pdf
- Coad, A., Segarra, A. & Teruel, M. 2016. Innovation and firm growth: does firm age play a role? *Research Policy*. 45(2):387-400.
- Cockburn, I.M. & Henderson, R.M. 1998. Absorptive capacity, coauthoring behavior, and the organization of research in drug discovery. *The Journal of Industrial Economics*. 46(2):157-182.
- Crépon, B., Duguet, E. & Mairessec, J. 1998. Research, innovation and productivity: an econometric analysis at the firm level. *Economics of Innovation and New Technology*. 7(2):115-158.
- Cucculelli, M. 2018. Firm age and the probability of product innovation. Do CEO tenure and product tenure matter? *Journal of Evolutionary Economics*. 28(1):153-179.

- Damanpour, F., Szabat, K.A. and Evan, W.M., 1989. The relationship between types of innovation and organizational performance. *Journal of Management Studies*. 26(6):587- 602.
- Damanpour, F., Walker, R.M. & Avellaneda, C.N. 2009. Combinative effects of innovation types and organizational performance: A longitudinal study of service organizations. *Journal of Management Studies*. 46(4):650-675.
- Das, T.K. & Teng, B. 2003. Partner analysis and alliance performance. *Scandinavian Journal of Management*. 19(3):279-308.
- Dosi, G., C. Freeman, R. Nelson, G. Silverberg, and L. Soete, eds. 1988. *Technical Change and Economic Theory*. London: Pinter.
- Egbetokun, A., Mendi, P. & Mudida, R. 2016. Complementarity in firm-level innovation strategies: A comparative study of Kenya and Nigeria. *Innovation and Development*. 6(1):87-101.
- Fagerberg, J. & Godhino, M. 2005. Innovation and Catching-up, in Fagerberg, J., Mowery, D., and Nelson, R. (eds.) *The Oxford Handbook of Innovation*, Oxford: Oxford University Press. 514-544.
- Fritsch, M. & Meschede, M. 2001. Product innovation, process innovation, and size. *Review of Industrial Organization*. 19(3):335-350.
- Gebreeyesus, M., and P. Mohnen. 2013. Innovation Performance and Embeddedness in Networks: Evidence from the Ethiopian Footwear Cluster. *World Development*. 41:302– 316.
- Goedhuys, M. & Veugelers, R. 2012. Innovation strategies, process and product innovations and growth: Firm-level evidence from Brazil. *Structural Change and Economic Dynamics*. 23(4):516-529.
- Guarascio, D., and M. Pianta. 2017. The gains from technology: new products, exports and profits. *Economics of Innovation and New Technology*. 26(8):779–804.
- Guisado-González, M. & Coca Pérez, J.L. 2015. Complementarity between different types of innovation: An oasis in the middle of the desert. *Esic Market*. 46(3):33-56.
- Gunday, G., Ulusoy, G., Kilic, K. & Alpkan, L. 2011. Effects of innovation types on firm performance. *International Journal of Production Economics*. 133(2):662-676.
- Hagedoorn, J. & Wang, N. 2012. Is there complementarity or substitutability between internal and external R&D strategies? *Research Policy*. 41(6):1072-1083.
- Hess, A.M. & Rothaermel, F.T. 2011. When are assets complementary? Star scientists, strategic alliances, and innovation in the pharmaceutical industry. *Strategic Management Journal*. 32(8):895-909.
- Kraft, K. 1990. Are product and process innovations independent of each other? *Applied Economics*. 22(8):1029-1038.
- Laursen, K. & Salter, A. 2006. Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal*. 27(2):131-150.

- Li, Y. & Rama, M. 2015. Firm dynamics, productivity growth, and job creation in developing countries: The role of micro-and small enterprises. *The World Bank Research Observer*. 30(1):3-38.
- Lokshin, B., Belderbos, R. and Carree, M., 2008. The productivity effects of internal and external R&D: Evidence from a dynamic panel data model. *Oxford Bulletin of Economics and Statistics*. 70(3):399-413.
- Love, J.H. & Roper, S. 2009. Organizing innovation: Complementarities between cross- functional teams. *Technovation*. 29(3):192-203.
- Mantovani, A. 2006. Complementarity between product and process innovation in a monopoly setting. *Economics of Innovation and New Technology*. 15(3):219-234.
- Martin, L. & Nguyen-Thi, T.U. 2015. The relationship between innovation and productivity based on R&D and ICT use. An empirical analysis of firms in Luxembourg. *Revue Économique*. 66(6):1105-1130.
- McPherson, M.A. 1996. Growth of micro and small enterprises in southern Africa. *Journal of Development Economics*. 48(2):253-277.
- Miravete, E.J. & Pernías, J.C. 2006. Innovation complementarity and scale of production. *The Journal of Industrial Economics*. 54(1):1-29.
- Mohnen, P. & Röller, L. 2005. Complementarities in innovation policy. *European Economic Review*. 49(6):1431-1450.
- Organisation for Economic Co-operation and Development [OECD]. 2018. *Oslo Manual 2018: Guidelines for collecting, reporting and using data on innovation*. Paris: OECD Publishing.
- Okumu, I.M., Bbaale, E. & Guloba, M.M. 2019. Innovation and employment growth: Evidence from manufacturing firms in Africa. *Journal of Innovation and Entrepreneurship*. 8(1):1- 27.
- Oxley, J.E. & Sampson, R.C. 2004. The scope and governance of international R&D alliances. *Strategic Management Journal*. 25(8-9):723-749.
- Peteraf, M.A. 1993. The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal*. 14(3):179-191.
- Reichstein, T. & Salter, A. 2006. Investigating the sources of process innovation among UK manufacturing firms. *Industrial and Corporate Change*. 15(4):653-682.
- Schmiedeberg, C. 2008. Complementarities of innovation activities: An empirical analysis of the German manufacturing sector. *Research Policy*. 37(9):1492-1503.
- Schneider, C. & Veugelers, R. 2010. On young highly innovative companies: Why they matter and how (not) to policy support them. *Industrial and Corporate Change*. 19(4):969-1007.
- Love, J.H. & Roper, S. 2009. Organizing innovation: Complementarities between cross- functional teams. *Technovation*. 29(3):192-203.
- Mantovani, A. 2006. Complementarity between product and process innovation in a monopoly setting. *Economics of Innovation and New Technology*. 15(3):219-234.

- Martin, L. & Nguyen-Thi, T.U. 2015. The relationship between innovation and productivity based on R&D and ICT use. An empirical analysis of firms in Luxembourg. *Revue Économique*. 66(6):1105-1130.
- McPherson, M.A. 1996. Growth of micro and small enterprises in southern Africa. *Journal of Development Economics*. 48(2):253-277.
- Miravete, E.J. & Pernías, J.C. 2006. Innovation complementarity and scale of production. *The Journal of Industrial Economics*. 54(1):1-29.
- Mohnen, P. & Röller, L. 2005. Complementarities in innovation policy. *European Economic Review*. 49(6):1431-1450.
- Organisation for Economic Co-operation and Development [OECD]. 2018. Oslo Manual 2018: Guidelines for collecting, reporting and using data on innovation. Paris: OECD Publishing.
- Okumu, I.M., Bbaale, E. & Guloba, M.M. 2019. Innovation and employment growth: Evidence from manufacturing firms in Africa. *Journal of Innovation and Entrepreneurship*. 8(1):1- 27.
- Oxley, J.E. & Sampson, R.C. 2004. The scope and governance of international R&D alliances. *Strategic Management Journal*. 25(8-9):723-749.
- Peteraf, M.A. 1993. The cornerstones of competitive advantage: a resource-based view. *Strategic Management Journal*. 14(3):179-191.
- Reichstein, T. & Salter, A. 2006. Investigating the sources of process innovation among UK manufacturing firms. *Industrial and Corporate Change*. 15(4):653-682.
- Schmiedeberg, C. 2008. Complementarities of innovation activities: An empirical analysis of the German manufacturing sector. *Research Policy*. 37(9):1492-1503.
- Schneider, C. & Veugelers, R. 2010. On young highly innovative companies: Why they matter and how (not) to policy support them. *Industrial and Corporate Change*. 19(4):969-1007.
- United Nations Department of Economic and Social Affairs [UN-DESA]. 2008. International Standard Industrial Classification of All Economic Activities Revision 4. United Nations Department of Economic and Social Affairs, Statistical Division. Statistical Papers Series M4. New York.
- Vega-Jurado, J., Gutiérrez-Gracia, A. & Fernández-de-Lucio, I. 2009. Does external knowledge sourcing matter for innovation? Evidence from the Spanish manufacturing industry. *Industrial and Corporate Change*. 18(4):637-670.
- Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal*. 5(2):171-180.
- World Bank & IFC. 2018. The Unseen Sector a report on MSME opportunity in South Africa. International Finance Corporation Report. Washington, D.C. Available: 2019-01- MSME-Opportunity-South-Africa.pdf (ifc.org).
- Wernerfelt, B. 1984. A resource-based view of the firm. *Strategic Management Journal*. 5(2):171-180.
- World Bank & IFC. 2018. The Unseen Sector a report on MSME opportunity in South Africa. International Finance Corporation Report. Washington, D.C. Available: 2019-01- MSME-Opportunity-South-Africa.pdf (ifc.org)

Notes

¹ Product innovations refer the introduction of products or services, while process innovation involve new processes introduced in the production of products or services. Internal innovation refers to innovation using 'in-house' firm resources while external innovation involves acquiring technology from outside the firm boundaries. Non-technological innovations, which are outside the scope of this paper, include organisational and marketing innovations. (OECD, 2018)

² The procedure requires that an available valid instrument explaining innovating decisions be included in the selection equation, but not in the main regression. We used owner's education and experience as the two exclusion variables. The justification is that an owner's levels of education and experience may affect the decision whether to innovate or not, but does not necessarily affect the kind of innovation strategy to adopt

³ For example, the WBES, which are the most widely used firm-level data internationally and particularly in Africa and other developing countries, do not include either informal enterprises or micro-enterprises (with fewer than five employees).

⁴ Ethical approval for the data collection and research project was granted by the College of Business and Economics Research Ethics Committee at the University of Johannesburg, ethical clearance code CBEREC19SEO01. The data is lodged with closed access in an online repository, doi:10.5281/zenodo.6484588

⁵ For the definition of MSEs in South Africa see https://www.gov.za/sites/default/files/gcis_document/201903/423041gon399.pdf and for an international definition see OECD Glossary of Statistical Terms - Small and medium-sized enterprises (SMEs) Definition

⁶ Government Gazette 2004, Vol. 472, No. 26866.

⁷ To assist in the stratification of the sample frame, the census exercise sought to obtain information on whether manufacturing was the primary activity (or not) of the businesses, the type of manufacturing involved, the size and age of the business, and whether the business was formally registered or not. The census activity enumerated 786 businesses involved in primary (639) and secondary (147) manufacturing activities. Of these, 86 were excluded from the survey as they over 50 employees. A total of 724 eligible businesses were enumerated and surveyed, of which the data was useable for 711, which is the full survey sample.

⁸ Specifically, firms were identified as having undertaken innovation if they indicated that they had introduced any of the following during the past financial year: entirely new products; significantly improved products; entirely new services; significantly improved services; entirely new processes; significantly improved processes. (Note that all firms that reported having undertaken service innovation also reported to have undertaken product or process innovation.)

⁹ The NACE-Rev. 1 refers to the industrial classification that link the European classification with the ISIC Rev. 3 (UN-DESA, 2008).

¹⁰ The responses include individual employee; individual external to the business; group of employees in your business unit; community of people external to the business; other enterprises or institutions; your enterprise together with other enterprises; friends/family members; users of your goods/services; other.

¹¹ It would have been ideal to also use additional measures of firm performance as robustness checks, but no suitable such variables were available or could be constructed from the dataset. For example, because the sales revenue variable is bracketed (not continuous), we are unable to construct a measure of productivity. The data also does not include direct measures of innovation output or innovation performance, such as the proportion of sales from innovation, which have been used as alternative dependent variables as in some related studies.

¹² Firms were asked: In the last financial year, how has the turnover of the business changed? Possible responses were: decreased; stay the same; increased.

Can technological innovations contribute to more overcome the issue of poverty reduction in Africa?

Charles Bertin Pilag Kakeu

University of Bamenda, Cameroon, Cameroon

Clovis Wendji Miamo , Clémence Zite Kouhomou

University of Dschang, Cameroun, Cameroun

Abstract

The objective of this research is to analyze the effects of technological innovations on poverty reduction using a panel of 36 sub-Saharan African countries over the period 2008 to 2019. By constructing an indicator of the use, adoption and adaptation of technological innovations and that of multidimensional poverty, we find that technological innovations significantly reduce poverty in sub-Saharan Africa. Our results survive several robustness checks. Taking into account the level of urbanization, it appears that technological innovations reduce poverty in countries with low urbanisation rates and increase it in countries with high urbanization rates. Finally, the analysis of mediation effects suggests that almost 30% of the total effect of the use, adoption and adaptation of technological innovations on multidimensional poverty reduction is through the improvement of productivity in the industrial sector while 62.5% is through the productivity of the agricultural sector. These results imply that poverty reduction policies in sub-Saharan Africa need to refocus on capacity building in the use, adoption and adaptation of technological innovations, particularly in the agricultural and industrial sectors.

Key Words: Technological innovation; digital economy; artificial intelligence; multidimensional poverty; agricultural sector productivity; industrial sector productivity.

1. Introduction

The study of how individuals can lift themselves out of poverty through technological innovation has become a central issue in economic development theory. Indeed, technological innovation has become one of the main mechanism to fight against poverty, challenging existing poverty research theories (Si et al., 2020). For example, in the past, the wealth of nations was primarily associated with the exploitation of natural resources (Smith, 1776) and the accumulation of physical capital (Solow, 1956). Today, however, it seems clear that a nation's wealth is largely related to its ability to produce and exploit new technological knowledge. Even Solow's (1987) paradox saying that "there can find the computer age everywhere except productivity statistics" now seems outdated (Gordon, 2000; Uchitelle, 2000). Beside the industrialized nations, technological innovation has enabled selected developing countries to reach middle-income status through increased competitiveness, inclusive employment and wealth creation (Santiago, 2014). Furthermore, the most relevant of technological innovation as a major factor for economic growth theory is highlighted in the definition of the Sustainable Development Goals (SDGs), particularly the 9th goal, which focuses on promoting inclusive industrialization and resilient infrastructure building, through investment in R&D and innovation. According to this goal, innovation and technological knowledge have become the main areas of action of the new global partnership for world inclusive development and solutions for poverty alleviation.

Although conventional wisdom places the dynamics of innovation almost exclusively in the domain of firm theory and the evolutionary school (Schumpeter, 1934; Penrose, 1959; Nelson et Winter, 1982), recent technological innovations have contributed to a more equitable distribution of societal benefits (Kouladouma et al., 2023). Similarly, investment in high technology, vocational training, cheaper products and/or more favorable external conditions help low-income people gain easier access to society (Levidow and Papaioannou, 2018). Even in Africa, where the challenges of absolute poverty and inequality remained long-standing problems (Khan et al., 2022 ; Kouadio and Gakpa 2022), where energy poverty and financial development is worsening, where economic structures continue to rely heavily on primary sectors, the production of raw materials and the exploitation of natural resources, economies have recently been overwhelmed by investment in information and telecommunications infrastructure (ICT), artificial intelligence and Internet using. For example, in low-income countries in sub-Saharan Africa, mobile phone subscriptions increased by 400% between 2005 and 2011, while the number of people using the internet has increased from 2.1 percent in 2005 to 24.4 percent in 2018 (ITU, 2018; Myovella et al., 2020). Moreover, sub-

Saharan Africa is the part of the world with the most countries in the "innovation learners¹" category. In 2022, the Global Innovation Index (GII, 2022) report ranked 5 sub-Saharan African countries among the 100 most innovative in the world (These are South Africa (61st), Kenya (88th), Ghana (95th), Namibia (96th) and Senegal (99th))². In addition to these five countries, the GII (2022) authors suggested that most of the countries in sub-Saharan Africa score above expectations given their level of development, ranking above average. Accordingly, there is substantial interest in improving our understanding of how technological innovation is integrate to inclusive development and the challenging of poverty alleviation in sub-Saharan Africa countries.

Indeed, an interest stream of research seems to support the view that African economies are undergoing a structural transformation, which is erasing the productivity slowdown, as well as inflation, the budget deficit and the business cycle (Adeleye and Eboagu, 2019; Niebel, 2018; Solomon and van Klyton, 2020; Myovella et al., 2020; Asongu et al., 2020; Appiah-Otoo and Song, 2021). Even the most pessimistic analysts, particularly in the popular press, agree that the use of technological innovation has changed almost everything and that African economies are growth niches driven by the dynamics of technological innovation, the digital economy and artificial intelligence (Adeleye and Eboagu, 2019). Also, the recent health crisis between 2019 and 2020 has resulted in improved economic growth in Africa (Pilag et al., 2021). Most of the countries on the continent that took advantage of the exceptional innovation revenues drawn from the experiences of developed countries during this period would have benefited from widespread and inclusive economic development. For Myovella et al. (2020), New technologies in sub-Saharan Africa play an important role in economic activity, especially in terms of access to ICT, small and medium size of enterprises participation in e-commerce and e-banking. Rodrik (2018) pointed out that although developed countries have some advantages in terms of technological innovation, this does not prevent developing countries from enjoying some benefits in increasing productivity, jobs creation and poverty alleviation. Recently, Kouladouma et al. (2023) has shown the positive and significant effect of technology transfers on subjective well-being in Africa.

However, while there is an optimistic literature on the relationship between technology adoptions, use and adaptation and growth in Africa, some authors seem somewhat pessimistic. For example, Acemoglu and Robinson (2013) argue that poor institutional quality and lack of infrastructure prevent developing countries from fully reaping the benefits of the digital revolution. Sammy et al. (2015) argue that the impact of digitalization on economic growth and productivity in low-income countries is likely to be slower because of the narrow competitive space and government control over the internet and ICT markets. Niebel (2018) also argues that the impact of digitalization on economic growth in developing countries can be mitigated by a lack of absorptive

capacity, sufficient human capital and complementary factors, such as research and development (R&D) capabilities. Also, the lag of financial development and the energy poverty that characterises developing countries can be a major constraint to enjoy the benefits of technological innovation. From the above, it is clear that the contribution of technological innovation on poverty reduction in developing countries remains an open debate. Accordingly, the research question emerge: Can technological innovations contribute to more overcome the issue of poverty reduction in Africa? If so, by what mechanism? And what are the economic policy implications?

Although there is an emergent stream of research namely Innovation for Inclusive Development (Santiago, 2014), the literature on the relationship between technological innovation and development remains fragmented across different perspectives, theoretical fields and academic discussions, preventing the creation of a genuine body of knowledge that can provide policy makers with critical theoretical insights and practical guidance on how to enjoy the benefits of technological innovations. Therefore, this study aims to propose a new theoretical framework for analyzing the effects of technological innovations on poverty reduction. Our theoretical framework is based on the concept of open innovation (Chesbrough, 2003; West et al., 2006). We hypothesize that technological innovations under the framework of open innovations contribute to poverty reduction in sub-Saharan Africa thanks to the capacities and opportunities that these tools offer for creating inclusive development in the agricultural and industrial sectors. To promote more inclusive and sustainable development in sub-Saharan Africa policies need to focus on building capacity for the use, adoption and adaptation of technological innovations, particularly in the agricultural and industrial sectors.

After this introductory section, section 2 focuses on the background of the study. Section 3 presents the methodological approach. In section 4, the results are presented and interpreted. Finally, section 5 concludes.

2. Background of the study

2.1. Overview of technological innovations

Innovation is a multidimensional concept. First, the term innovation refers to the process of creating and introducing new methods and production processes, such as equipment, techniques, techniques and ideas (Friis-Hansen and Egelyng 2007). According to Schumpeterian analysis, innovation is a process that leads to a product: this product could be novel in the sense that it is an object or a way of doing that previously did not exist somewhere before. Innovations can start from scratch, adapt or substantially modify existing creations, or introduce new and improved methods and devices into society (Shearmur, 2012; Mhula Links et al., 2014). It can be a single fundamental improvement, or a series of small incremental improvements that lead to significant improvements in the

method over time (Assefa et al., 2009). It may also involve adopting and adapting certain production methods that have been successful in different situations or at different times.

Furthermore, innovation differs from invention in that it concerns not only the creation of new approaches or things, but also the exclusivity of their use (Shearmur, 2012). For example, an innovation is not considered an innovation if it is only used by its inventor (Assefa et al. 2009). On this basis, a notable difference between developed and developing countries is that developed countries produce innovations (they are inventors) while developing countries are only users of these innovations (Myovella et al., 2020). Moreover, developed countries have already built a large body of physical infrastructure, human capital, and appropriate financial and political institutions that strengthen and expand their capacity to generate innovation (Dewan and Kraemer, 2000).

Basically, innovation refers to creativity or the way people develop ideas, skills, behaviors, etc. within a given community. This can contribute to solving problems, even if it is not considered innovative in other parts of the world. In fact, most existing definitions of innovation suggest that it takes place in a community, region or place, involving people, enterprises and physical and human resources in the same community working to solve problems such as poverty alleviation, scarcity, or seeking to gain a competitive position. In any case, since Schumpeter's seminal work, numerous definitions of innovation have been conceptualized at the level of firms and universities, highlighting the concept of research and development (R&D) and considering innovation as the driving force behind the performance of firms, or the essential element of growth at the level of the State.

Chesbrough (2003) presents a more complete analysis of the concept of innovation. He concluded that the concept of innovation was undergoing a paradigm shift, from a closed model, based on R&D activities, to an open model, based on adaptive innovation. This conclusion draws heavily on earlier work on industrial evolution (Nelson and Winter, 1982), absorptive capacity (Cohen and Levinthal, 1990) and the impact of spillovers on industrial R&D (Rosenberg, 1994). According to Chesbrough, open innovation is both a set of practices for taking advantage of innovation and a cognitive model for creating, interpreting, adapting and studying these practices. Some of these practices are not new. For example, government funding agencies and not-for-profit foundations have been funding scientific research for over 50 years, playing the role that Chesbrough (2003) has described as the 'benefactor of innovation' (Gassmann et al., 2010).

2.2 How can technological innovations reduce poverty in Africa?

2.2.1. Let's take a look at the history

The role of innovation in improving people's lives condition and reducing poverty is not new to modern economics. Indeed, although the concept of innovation was not yet in vogue, the use of knowledge to build wealth goes back to ancient societies such as Egypt and ancient Greece. For example, in order to prevent people from starving during major food shortages, the Pharaohs used highly advanced techniques and methods not only to improve agricultural productivity, but also to manage and distribute the harvest fairly among landowners and farmers. In the Nile region, innovative agricultural practices have been implemented to the great benefit of the local population, through irrigation techniques, the use of ploughs and improved productivity. Otherwise, it is easy to find examples illustrating the thesis that technology may have something to contribute to poverty reduction (Dyson et al., 2001). For example, long ago, 'first generation' technological innovations made a practical contribution to poverty reduction and social justice in Africa during the colonial period in particular were those of public health, especially in the areas of drinking water supply, sewage treatment, vaccination, penicillin. Indeed, these innovations could only effectively protect the colonists from contagion and certain tropical diseases if they were also accessible to the poorest.

In 1776, Adam Smith published a landmark work entitled "The Wealth of Nations". In this book, Smith describes the scenario of workers developing machines to reduce the workload of labourers (Dosi and Nelson, 2010). This book gave rise to the classical theory of growth. Indeed, history tells us that the majority of the population worked in livestock and agriculture until the 18th century. Working conditions for those employed in livestock and agriculture were harsh and income levels were low. Over time, productivity in agriculture increased due to technological advances (Çalışkan, 2015). With the increase in productivity, production also increased and agricultural workers started to migrate to the industry sector. The incomes of people migrating to industry sector increased and it seems that their living conditions also increased, leading to a virtuous circle between innovation, improved productivity and improved living conditions (Burrus et al., 2018). Innovation is therefore an important factor in the fight against poverty through inclusive employment.

2.2.2. The mediating effect of inclusive employment

There is a large literature on virtuous circles between technological change and productivity improvement. However, a better understanding of the technological innovations on poverty reduction requires new theories of well-being, in particular in relation to the capabilities, chances and opportunities of realization (Sen, 1992; 1999; Alkire, 2005). For Sen, income inequalities between individuals are not assessed solely in terms of their resource endowments but also in terms of their ability to convert them into real freedoms. He thus introduces the notion of "capabilities", which invites to consider poverty beyond its monetary aspects and to think of it in terms of freedom of action, capacity to do, opportunity and chance offer (Maguain, 2002). From the above,

it is clear that technological innovations in all aspects of the economy can be understood within a capability option. Even if Sen had not focused his thinking on technological innovations, the poverty and inequalities between people are not just about their resource endowments but about their capacities to convert the opportunities offered by the internet, mobile phones and computers into real freedoms. In parallel with global technological advances, the use of ICTs in African countries has also caught up, helping to create decent jobs (Egyir, et al., 2020; Myovella et al., 2020).

Additionally, various studies show that technologies innovation can increase productivity and economic growth by enabling more efficient business processes and maximizing the effective use of resources (Karner, and Onyeji, 2007). Actually, the poorest operate mainly in the informal sector and survive with high transaction costs. Technological innovation and the adoption of the digital economy therefore contribute to poverty reduction by providing opportunities to include poor, vulnerable and marginalized groups into modern production processes (Ling, 2008; Horst and Miller, 2005). There is also a body of literature investigating the role of ITC as a tool for productive use, job search, small business skill building, and contribution to remote population integration through e-commerce, e-banking and e-learning (Galperin, 2005; McNamara, 2003).

In general, one of the channels through which technological innovation impact poverty reduction is through the way it transforms different modes of production, reduces transaction costs (Bojnec and Fertő, 2012; Myovella et al., 2020). Technological innovation has played a key role in reducing poverty and promoting growth by involving the rural poor, who have limited access to almost all essential services such as water, electricity, education and health, etc. Hofman et al (2016) argue that digitization contributes to economic growth through (a) meeting demand for digital products such as computer hardware and software, and (b) increasing productivity and investment in sectors using ICT. Mittal and Tripathi (2009) argue that the use of ICT can provide a solution to information asymmetry in various lagging sectors such as agriculture, positively impacting on farmers' profitability by reducing (i) input and output transaction costs, (ii) research costs due to time savings and (iii) travel costs. Peña- Vinces et al (2012) argue that SMEs in developing countries do tend to imitate best practices and technological innovations from developed countries, which has a significant positive impact on their international competitiveness and poverty reduction through income growth and improved living conditions. The best way for technological innovations to reduce poverty is to provide poor with financial services such as microfinance, education and capacity building, and information on the organization of production structures and the functioning of the labour market. Aker and Mbiti (2010) point out that the adoption of telecommunication technologies not only played a transformative role in increasing the GDP of African countries, but also completely

transformed people's lives condition. Based on the above, we formulate the following hypothesis.

Hypothesis: technological innovations contribute to poverty reduction in sub-Saharan Africa through the opportunity that they offer to create inclusive employment in the agricultural and industrial sectors.

3. Data and methodological approach

3.1. Data

In order to examine the effects of technological innovation on poverty alleviation, this study covers a panel of 36 sub-Saharan African countries, from 2008 to 2019. For this purpose, several data sources were used: World Development Indicators (WDI), World Governance Indicators (WGI) and United Nations Conference on Trade and Development (UNCTAD). It should be noted that the periodicity and the countries selected are carefully chosen according to the literature and data availability constraints. The full description of the data is as follows.

3.1.1. Dependent variable: poverty measure

Our dependent variable is multidimensional poverty. Despite the United Nations Council's repeated commitment to halve poverty by 2030, there is still no official definition of poverty, nor its standard measurement. Indeed, poverty can be defined as all monetary and non-monetary deprivation. In addition to lack of income, access to quality healthcare, education and housing, as well as the quality of the environment and governance, are all factors that affect people's well-being (Rodríguez-Pose and Tselios, 2019). Consequently, the literature has developed the concept of multidimensional poverty from Sen's seminal work. Indeed, several poverty indices have been proposed, but Sen's index of social well-being (1973, 1974, and 1976) remains the most widely used. Sen's index takes into account the trade-off between the maximization of benefits (i.e. economic, social and political benefits), on the one hand, and an equitable distribution of these benefits, on the other. Compared with other indices that rely heavily on GDP (England 1998; Torras 2008), Sen's index has the advantage of giving equal weight to the distributive effects of wealth. We therefore use the Sen Index as an indicator of multidimensional poverty in this study (Rodríguez-Pose and Tselios, 2019).

Moreover, multidimensional poverty is determined by what Sen (1985) called capabilities and functionings (Muller and Trannoy 2011). Capabilities are what people are capable of doing or being, while functionings represent the things a person actually does and experiences. This approach seems particularly relevant for measuring poverty because it focuses on people's capability to achieve goals they consider important, based on the resources they have (Doucet and Duplantie, 2017). Income is only one dimension of these capacities

and functionings. This has been recognized in the development of the United Nations Human Development Index (HDI), which takes a more holistic view of development. The HDI is based on three attributes: real GDP per capita in purchasing power parity (income), education - measured by the adult literacy rate and gross enrolment ratios in primary, secondary and tertiary education - and health - represented by life expectancy at birth (Rodríguez-Pose and Tselios, 2019).

So, as with economic development, poverty reduction goes far beyond aspects of income. Education, health and living standards, among a range of other factors, largely determine people's well-being. This is why, in this document, we use Sen's conceptual framework of poverty based on three dimensions (standard of living, health and education) assessed using eight indicators. Two indicators measuring the level of education (secondary school completion rate and gross enrolment ratio). Two indicators measuring health (life expectancy at birth and food production index) and four indicators measuring living standards (proportion of population with access to electricity, percentage of population using clean cooking fuels and technologies (percentage of population using water from at least basic or improved water sources for cooking). The eight indicators are taken from the World Development Indicators (WDI, 2021). From these eight variables, an indicator of the level of well-being is constructed using the principal components analysis method. We assume that this indicator is strongly influenced by the use and adoption of technological innovations.

3.1.2. Variable of interest

Our main independent variable is technological innovation. Indeed, innovation is a term that means the development of new products, processes and ideas. Therefore, although most authors measure innovation by R&D or patent applications, it is difficult to measure it with only one dimension. Oltra et al. (2008) suggest that patents are a useful measure of a country's levels of inventiveness and technological strength. However, they acknowledge that patents may not fully capture innovation, as only a fraction of ideas are patented, and the number of patents does not reflect the value of patented inventions. Similarly, some companies, in order to protect their innovativeness, choose to resort to secrecy, as patenting implies revealing information about the innovation. Noted that, the act of innovation is not entirely free and requires investment in human and material resources as well as ICT infrastructure and appropriate financial and political institutions. Indeed, in developing countries, where most technological innovations are imported, their use, adoption and adaptation requires access to finance, but also people with the appropriate skills. Similarly, research and development activity requires the development of the financial sector, skilled researchers, but also a high level of information and communication technology (ICT) infrastructure. Therefore, we constructed a technological innovation indicator using four dimensions. The first dimension,

which measures the amount of R&D activity, considers the number of publications and patent applications for 11 important technologies in the nation. The infrastructure level of information and communication technology (ICT) is the subject of the second dimension of the innovation variable, and measure by the infrastructure's quality, and its prevalence. The third dimension considers access to finance, notably the domestic credit to the private sector. The final dimension considers technical skills, notably the general education level of the population as measured by years of schooling, and the International Standard Classification of Occupations (ISCO). The United Nations Conference on Trade and Development (UNCTAD) database served as the source for these indicators.

3.1.3. Control variables

This study aims to examine the outcomes of the use, adoption and adaptation of technological innovation on poverty reduction in sub-Saharan Africa. Thus, in order to avoid omitted variables bias and be in line with the literature on poverty reduction factors (Kraay, 2006; Besley and Burgess, 2003; Ravallion and Chen, 2007; Klein et al, 2001; Magombeyi and Odhiambo, 2017; Si et al, 2021; Osabohien et al, 2019; Islam, 2004; Cervantes-Godoy, and Dewbre, 2010), our study takes into account seven control variables. These are: (i) GDP per capita, (ii) foreign direct investment (outflow); (iii) the proportion of self-employed; (iv) the proportion of employment in the agricultural sector, (v) the proportion of employment in the service sector; (vi) the proportion of employment in the industry sector; and (vii) the useful resource rent. All this variables are extracted from the World Development Indicators (WDI, 2021). Table 1 presents descriptive information on all the variables in the study.

Descriptive Statistics

Variable	Obs	Mean	Std. Dev	Min	Max	Source
Access to electricity	444	42.367	27.606	.4	100	WDI
Basic sanitation	421	39.847	20.555	11.984	98.39	WDI
Clean fuel cooking	444	23.026	29.595	.2	100	WDI
Drinking water	444	64.024	20.009	7.85	93.501	WDI
Lower secondary completion	307	44.133	23.333	8.45	99.077	WDI
School enrolment	279	46.071	27.367	4.245	109.444	WDI
Food production index	418	91.586	24.677	5.078	155.8	WDI
Life expectancy	441	62.647	20.139	2.357	151.359	WDI
ICT	432	.166	.148	0	.924	UNCTAD
Skills	432	.227	.163	0	.88	UNCTAD
RD	432	.082	.132	0	.716	UNCTAD
Access finance	432	.431	.187	0	.946	UNCTAD
Ln GDP	435	7.283	1.098	5.628	11.39	WDI

Ln FDI	288	17.517	2.81	9.205	25.934	WDI
Self-employed	444	62.186	23.494	14.13	93.11	WDI
Employment in agriculture	444	39.442	25.662	.45	89.11	WDI
Employment in industry	444	18.15	16.699	2.59	76.88	WDI
Employment in services	441	45.119	153.69	0	2400	WDI
Ln natural resource rent	440	1.637	1.859	-6.749	4.139	WDI

3.2 Methodology

In order to analyze the effect of use, adoption and adaptation of technological innovations on the improvement of people's living conditions, we estimate a linear equation model inspired by previous work on the determinants of poverty.

Our theoretical model is written in the following form:

$$Poverty_{it} = \beta_0 + \beta_1 Innovation_{it} + \beta_3 X_i + \varepsilon_{it} \quad (1)$$

Where *Poverty_{it}* is the composite indicator of multidimensional poverty constructed by the principal component analysis (PCA) method (see Anselin (2002) for methodology of constructing composite indicators). *i* is the country index and *t* the time period. *Innovation_{it}* is the composite indicator of the technological innovations. *X_{it}* is the vector of control variables including foreign direct investment (outflow), GDP per capita, natural resource rents, total employment in the service, agricultural and industrial sectors and self-employment. *ε_{it}* is the error term which follows a normal distribution. Since the dependent variable is a continuous variable, the most appropriate estimation technique is ordinary least squares (OLS). Although the countries studied share some similarities (geographical and cultural proximity, colonial heritage, etc.), it is important to control for individual heterogeneity. In this configuration, the OLS method provides a non-convergent estimator. For this reason, we use a fixed-effects model that can account for unobserved heterogeneity across countries. Indeed, for different institutional backgrounds and different degrees of development and urbanization, the use of fixed effects leads to the assumption that there are specific effects in each country that somehow affect the level of poverty. In this configuration, the theoretical model is written as:

$$Poverty_{it} = \beta_0 + \beta_1 Innovation_{it} + \beta_2 X_i + \mu_t + \nu_t + \varepsilon_{it} \quad (2)$$

Where *μ_t* is the unobserved country-specific effect and *ν_t* is the time-specific effect. The inclusion of country- and time-specific effects puts the model in the context of panel models. However, panel data also suffers from cross-sectional

dependence. Indeed, a major issue inherent in panel data studies that can affect the estimation of inference parameters is the possible interdependence of individual units (Sarafidis and Wansbeek, 2010). This concept of spatial dependence has been known in the social sciences since his 1930s, well before the advent of panel econometrics. For example, in the field of economic geography, Tobler (1970) found that: "Everything is connected to everything. But what's close is more relevant than what's far away." For Stephan (1934, p. 165), "When dealing with social data, it is known that individuals, groups and their characteristics are dependent on each other and, because of their social characteristics, are not independent. Hence the importance of considering issues of interdependence between variables in our study. Therefore the estimation method of Driscoll and Kraay (1998) was used to solve the problem. In fact, the Driscoll and Kraay model assumes an interdependent relationship between the variables, which may not exist in the fixed effects method.

Indeed, another problem likely to weaken our estimators is that of the endogeneity between the explanatory variable and the one being explained. This endogeneity translates into the fact that the variable of interest, which is an indicator of technological innovation, is both an explanatory variable of the level of poverty, but a variable explained by the other traditional determinants of poverty. Also, the endogeneity problem may arise due to reverse causality between technological innovation and improved living conditions, but also due to omitted variable bias. Regarding the reverse causality relationship, it is likely that the use, adoption and adaptation of technological innovations can lead to improved living conditions of people, in turn, high levels of poverty can influence the use, adoption and adaptation of technological innovations, especially to address problems of hunger, malnutrition, health, etc. For the case of our study, taking into account the possibility of endogeneity between dependent and variable of interest in the following equation:

$$\begin{aligned} \{Poverty_{it} &= \beta_0 + \beta_1 Innovation_{it} + \beta_3 X_i + \varepsilon_{1t} \\ Innovation_{it} &= \beta_0 + \beta_1 X_i + \varepsilon_{2t} \end{aligned} \quad (3)$$

With

$$\begin{aligned} \{\varepsilon_{1t} &= \alpha_1 B + \epsilon_1 \\ \varepsilon_{2t} &= \alpha_2 B + \epsilon_1 \end{aligned} \quad (4)$$

where B denotes the set of variables not observed at the country level that affect both the level of multidimensional poverty and the level of technological innovation. ϵ_1 and ϵ_2 are idiosyncratic error terms. To address this endogenous problem, there are several methods, and among these methods the instrumental variables method is the most popular. In practice, however, it is often difficult to find a suitable means of simultaneously satisfying the conditions of internal validity and consistency, posing a significant problem for the use of instrumental variable estimators in most applied research. To address this type of problem, Lewbel (2012) proposes a variant of means variable modeling in which means can be generated from internal variables when suitable external

means are available. Lewbel (2012) argues that if the data have heteroskedasticity, the internally generated tool is given by:

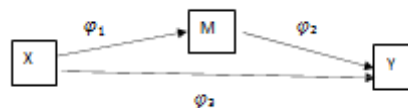
$$= (X_i - \bar{X}) \quad (6)$$

where Z_i is an instrument vector generated from internal variables. X_i is the vector of control variables, $\bar{X}$ is its mean, and ε is the error term. Lewbel's approach is essential for identifying structural parameters in regression models using endogenous or poorly measured regressors in

the absence of conventional identifying information (Chirchill and Farell, 2017). This method consists of control variables and includes instruments based on heteroscedasticity. Instruments are generated from each exogenous variable in the residual of the basic equation multiplied by the mean centered form. The advantage of the Lewbel approach is that it does not rely on the satisfaction of standard exclusion constraints. Therefore, our study mobilizes the Lewbel approach to solve endogenous problems.

Noted that, the methodological strategy adopted assumes that there is a direct effect between the adoption, use and adaptation of technological innovations and the improvement of people's living conditions. However, it is interesting to highlight the transmission channels through which the use, adoption and adaptation of innovations can influence poverty levels in an economy. Such an analysis will not only improve the understanding of the link between technological innovation and poverty reduction, but also put into perspective the levers that policy makers should use to improve the effectiveness of technological innovations in achieving sustainable development goals. Thus, we hypothesize that the impact of the adoption, use and adaptation of technological innovations on poverty reduction is mediated by employment levels in the agricultural, industrial and service sectors, but also by levels of self-employment. From the evidence of capability theory, it would seem that the adoption, use and adaptation of technological innovations improves productivity in the agricultural, industrial and service sectors, but also in the self-employment sector, leading to higher wages and therefore to the reduction of non-monetary poverty (access to health care, clean energy, good housing, basic sanitation, etc.). Therefore, we analyze mediation effects to identify these potential routes of infection. In fact, a mediation effect refers to the mechanism by which an independent variable X influences a dependent variable Y through an intermediate variable M (MacKinnon, 2008). The mediation effect is shown schematically in Figure 1

Figure 1: Modelling the mediation effect



From this Figure 1 it is clear that mediation effect can be divided into two branches: direct and indirect effects. In a simplified way, two regression equations allow us to test these effects. Equation (7) allows us to model the effect of X on M, the mediating variable, and equation (8) allows us to model the effect of X on Y :

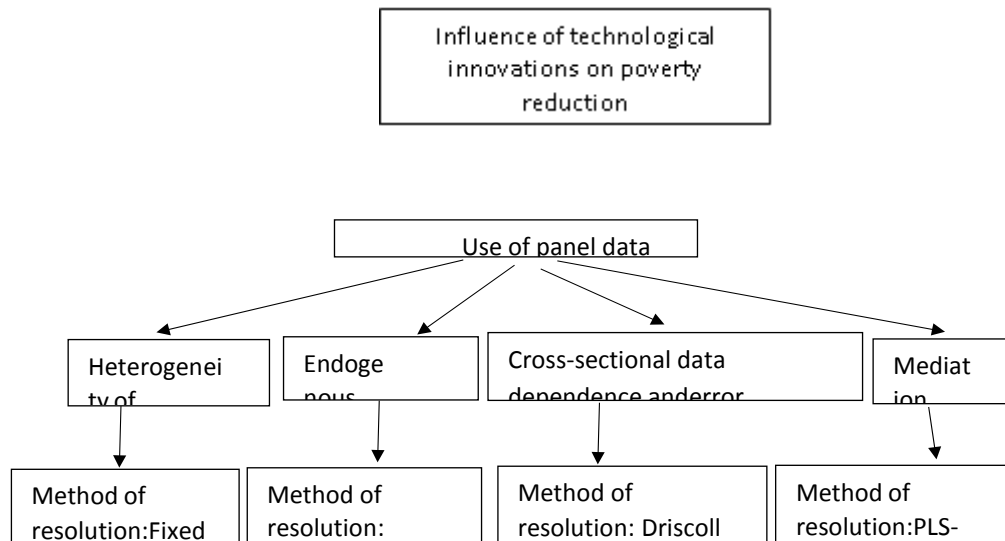
$$M = \varphi_0 + \varphi_1 X + \mu \quad (7)$$

$$Y = \theta_0 + \varphi_2 X + \varphi_3 M + \mu \quad (8)$$

Where φ_1 is the direct effect of X on M ; φ_2 is the direct effect of M on Y. The indirect effect of X on Y is obtained as follows: $\varphi_1 \times \varphi_2$. Consequently, the total effect of X on Y is obtained by adding the direct and indirect effects : $\varphi_1 \times \varphi_2 + \varphi_3$.

Several methods are used to estimate equations (7) and (8), notably by estimating them individually or simultaneously. In our study, we adopt the structural equation method associated with the partial least squares method (PLS-SEM) (Venturini, and Mehmetoglu, 2019). Without loss of generality, the objective of this sub-section was to outline the methodological approach to analyzing the impact of the use, adoption and adaptation of technological innovations on poverty reduction. Figure 2 represents the synoptic diagram of this methodological approach

Figure 2: Synoptic diagram of the methodological approach



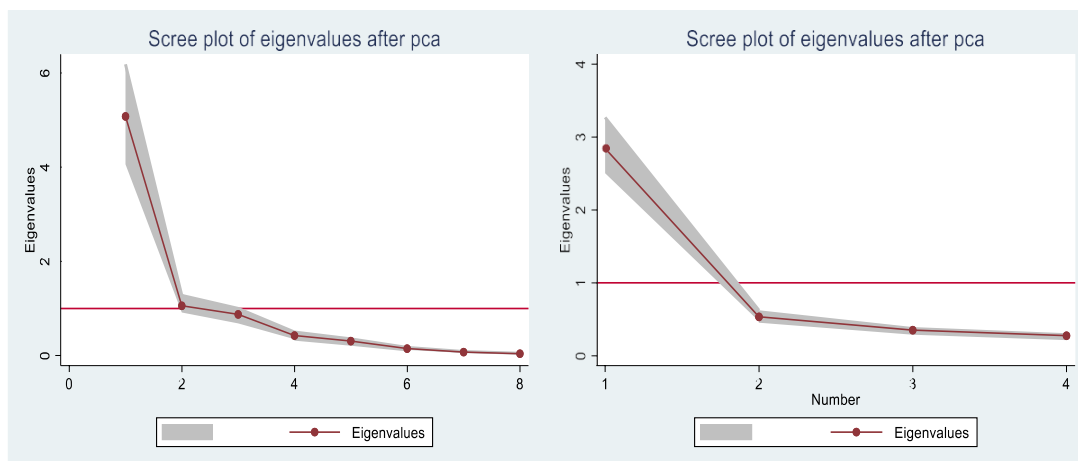
4. Results and interpretations

The presentation of results and discussion follows the methodological synthesis shown in Figure 2. First, in section 4.1, we present preliminary results on the construction of multidimensional poverty and innovation indicators by the PCA method, followed by an analysis of the correlation between the two indicators. Section 4.2 presents baseline estimates using fixed effects and the Driscoll-Kraay method. 4.3 show the robustness of the results.

4.1. Indicator Construction and Correlation Analysis

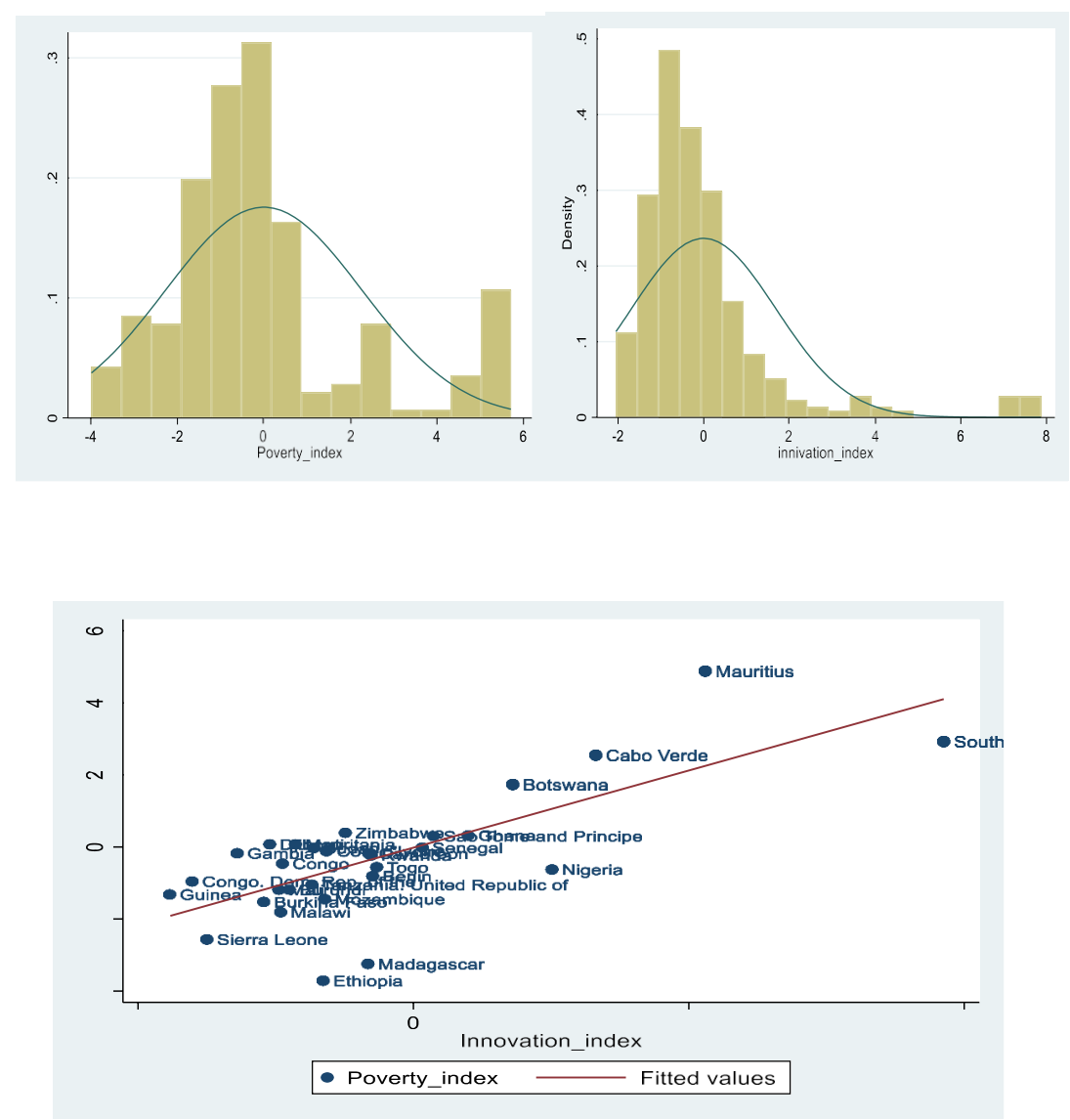
The construction of indicators is made possible by principal component analysis (PCA). Theoretically, PCA is a method for creating new variables that are linear compositions of the original variables. Figure 3a represents the construction of the multidimensional poverty indicator, while Figure 3b refers to the construction of the technological innovation indicator. Regarding Figure 3a, based on the Kaiser criterion, we can see that there are two principal components with eigenvalues ≥ 1 and the kink point also at the same point. This means that to avoid loss of information, our multidimensional poverty indicator is the linear combination of the first 2 factors (Figure 3a). On the other hand, for the innovation indicator, only the first factor has an eigenvalue greater than 1. This means that the essential information is contained in the first factor (Figure 3b). Concerning the validity of our indicators, the calculation of the crumbach alpha is 0.85 for the innovation indicator, against 0.90 for the multidimensional poverty indicator. These values are well above the 0.70 recommended in the literature, proving that our indicators are valid. Figure 4 shows the distribution of the two indicators, following the density of a normal distribution. Both distributions are slightly skewed to the right, even the poverty distribution seems to have outliers. Figure 5 shows a positive correlation between our technological innovation indicator and the multidimensional poverty indicator.

Figure 3: Eigenvalue diagram



This result means that technological innovations are positively correlated with multidimensional poverty reduction in sub-Saharan African countries, all else being equal. However, given that correlation is not synonymous with causality, this relationship will be studied empirically in the next subsection.

Figure 4: Distribution of indicators according to the density of the normal distribution



4.2 Preliminary regressions (fixed effects and cross-sectional dependence)

Table 2 shows the results of the estimation of equation 2. Column 1 shows the results of the fixed effect. The first finding that emerges from this effect is that technological innovations positively and significantly influence our poverty reduction indicator at the 10% threshold. This result implies that the use,

adaptation or utilization of technological innovations by 1% influences human capital formation or poverty reduction by 12.5%. These results take into account the specific characteristics of each country. Indeed, even if there is a global trend in the fight against poverty and the promotion of the digital economy and artificial intelligence, each country has its own policy orientations, depending on its institutional context, its level of development, and especially the level of its human capital. All these differences are taken into account in our results through the estimation of a fixed effect model. However, even if each country defines its own policy orientations with respect to poverty reduction and the use, adoption and adaptation of technological innovations, these results may be influenced by cross- country dependence and spatial autocorrelation of errors.

Column 2 in table 2 shows the results of estimating equation 2 with cross-sectional data dependence taken into account. Indeed, the estimation of equation 2 by the Driscoll and Kraay method reported in column 2 leads to a much more significant relationship at the 1% threshold between technological innovations and poverty reduction index. Indeed, the results show that when spatial dependence is taken into account, the effect of innovation on poverty reduction is almost three times as large, all else being equal. This result indicates that beyond country- specific considerations and characteristics, taking into account interdependencies between countries improves the results. The argument behind this result is that although some innovations occur in certain countries, or certain types of innovation are over-represented in certain countries, or the consequences of innovation are more visible in certain countries, such as efficient wages, human capital, well-trained labour and poverty reduction, innovation that occurs in a country may depend on activities that take place outside that country.

Table 2: Baseline regression (all sample)

VARIABLES	Fixed effects Poverty	Driscoll-Kraay Poverty
Innovation_indexLn GDP	0.125* (0.0715) .198*** (0.398)	0.337*** (0.0629) 0.858*** (0.0956)
Ln FDI	0.0238 (0.0144)	-0.0810** (0.0351)
Ln Natural resource	-0.173** (0.0784)	0.0536** (0.0194)
Ln Employment in Agriculture	-0.190 (0.251)	-0.641*** (0.0755)
Ln Emploi in Services	.957*** (0.275)	.005*** (0.106)
Ln Employment in Industry	-0.306 (0.289)	-1.194*** (0.0795)

Ln self-Employment	0.0188 (0.133)	0.0997* (0.0520)
Constant	-17.62*** (3.258)	2.930*** (0.815)
Comments	444	444
R-squared	0.699	0.930
Number of groups	23	23
F	28.20	7412.82
Prob > F	0.0000	0.0000

Benin, Botswana, Burkina Faso, Burkina Faso, Burundi, Cabo Verde, Cameroon, Congo, Rep. of Congo Dem, Côte d'Ivoire, Djibouti, Gabon, Gambia, Ghana, Guinea, Kenya, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Sao Tome and Principe, Senegal, South Africa, United Republic of Tanzania, Togo, Uganda, Zambia, Zimbabwe, Mauritania, Mauritius, Madagascar, Ethiopia, Sudan, Sierra Leone, South Sudan,

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Thus, through a diffusion effect, an innovation may be produced in one country, but its effects in terms of poverty reduction and human capital formation are observed in another country. These results are consistent with Stephan's (1934, p. 165) conclusion that 'when dealing with social data, it is known that by virtue of their very social character, persons, groups and their characteristics are interdependent and not independent'.

4.3. Robustness check

Several tests are performed to confirm the robustness of previous results. First, the model is estimated by homogenizing the panel, then multiple estimation techniques are used to fix possible endogenous problems.

4.3.1. Homogenization of our panel

The homogeneity of our panel is based on the level of urbanization. Indeed, while previous work has focused on the role of ICTs on economic growth, this research focuses on the relationship between technological innovations and multidimensional poverty, by taking into account the level of urbanization. Indeed, based on the fact that innovation leads to economic growth (Schumpeter, 1934) and influenced in part by endogenous growth theory (Romer, 1990; Howitt, 2010), urbanization generate the internal dynamics necessary for innovation, that leads to regional development (Hassink et al., 2004; Asheim et al., 2011). Cities are an important part of the global economy, responsible for the majority of economic activity in every country in the world (Krugman and Elizondo, 1996; Florida, 2002). They are naturally the focus of attention when issues of poverty reduction in relation to innovation are discussed.

In Table 3, our analyses have been carried out taking into account the level of urbanization of the countries in the sample. The results of this table show a positive and significant relationship between the technological innovation index and the human development index in countries with a low level of urbanisation, regardless of the estimation method. However, this relationship is negative and significant in the country with high urbanisation. In simple terms, this result implies that, considering the cross-sectional dependency model, a 1% increase in technological innovations reduces poverty by 32.1% in low urbanized countries and increases it by 24.5% in highly urbanised countries, all other things being equal. This result seems somewhat counterintuitive. However, a simpler explanation is that technological innovations, artificial intelligence or the digital economy contribute directly or indirectly to the increase in poverty in large cities, through re-skilling, over-skilling and the loss of urban jobs. Indeed, the concept of 'inclusive innovation' (Heeks et al., 2014; Chataway et al., 2014; Odame et al., 2020) is being developed in response to a growing realization that capital-intensive innovations generally lead to social exclusion, particularly for low-income people (Levidow and Papaioannou, 2018) in large cities.

Overall, the results in table 3 suggest that the 'triumph of the big cities' is somewhat overstated in poverty reduction. It clear that the adoption, use and adaptation of technological innovations reduce poverty in small cities and increase it in large cities. This result is in line with Appiah- Otoo and Song (2021), who find that poor countries, with low levels of urbanization, tend to benefit more from the ICT revolution compared to developed countries, with high levels of urbanisation. Another interesting strand of the literature reveals that technological innovations are a source of deindustrialization, job loss (Rodrik (2018; 2015) and, consequently, an increase in the risk of poverty in large metropolitan areas. As Rodrik (2018) has argued, this trend is seen as 'premature deindustrialization'.

Table 3: Heterogeneity according to the level of urbanisation

VARIABLES	Low Urbanization		High urbanisation	
	Fixed effects	Driscoll-Kraay	Fixed effects	Driscoll-Kraay
	Poverty	Poverty	Poverty	Poverty
Innovation_index	0.228*** (0.0676)	0.321** (0.118)	-0.188 (0.137)	-0.245*** (0.0714)
Ln GDP	1.485*** (0.354)	0.789*** (0.159)	5.026*** (1.114)	0.120 (0.214)
Ln FDI	-0.00999	-0.0979*	0.0801***	0.0223

	(0.0146)	(0.0469)	(0.0262)	(0.0251)
Ln Natural resource	-0.180**	-0.372***	-0.248	0.212**
	(0.0733)	(0.0809)	(0.161)	(0.0817)
Ln Employment in Agriculture	-0.430*	-0.00726	0.515	-0.828***
	(0.229)	(0.215)	(0.668)	(0.0772)
Ln Emploi in Services	0.937***	0.680***	-0.783	3.678***
	(0.206)	(0.196)	(2.091)	(0.230)
Ln Employment in Industry	-0.288	-0.609**	-0.165	-0.202
Ln self-Employment	(0.250)	(0.197)	(0.853)	(0.269)
	0.106	0.00224	-0.0896	0.633***
	(0.113)	(0.0164)	(0.332)	(0.0714)
Constant	-10.94***	-4.262**	-35.83***	-12.40***
	(2.784)	(1.556)	(7.547)	(1.530)
Comments	216	216	218	218
R-squared	0.787	0.977	0.760	0.937
Number of groups	14	14	10	10

Hihgh urbanization countries (Botswana, Cabo Verde, Cameroon, Congo, Congo. Dem. Rep. of the, Côte d'Ivoire, Djibouti, Gabon, Gambia, Ghana, Mali, Namibia, Nigeria, Sao Tome and Principe, Senegal, South Africa, Zambia, Mauritania); low urbanization countries (Benin, Burkina Faso, Burundi, Guinea, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Togo, Uganda, Zimbabwe, Mauritius, Madagascar, Ethiopia, Sudan, Sierra Leone, South Sudan) Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4.3.2. Endogeneity problems

4.3.2.1. Correction of endogenous reverse causality

Lewbel's method is useful for solving the problem of endogeneity linked to reverse causality. Overall, Lewbel's estimation results (Table 4) show that technological innovations positively and significantly influence the multidimensional poverty reduction index in the total sample. Also, we observe an improvement in the coefficient of the technological innovation index contrary to the model that does not take into account the correction for endogenous effects. However, by decomposing the panel, we obtain a non-significant coefficient, but positive for the low urbanized countries and negative for the high urbanized countries

Table 4: Control of endogeny

VARIABLES	Lewbel(2012)		
	All sample Poverty	Low urbanization Poverty	High urbanization Poverty
Innovation_index	0.340*** (0.0942)	0.0899 (0.178)	-0.144 (0.115)
Ln GDP	0.857*** (0.140)	0.793*** (0.122)	0.139 (0.236)
Ln FDI	-0.0812*** (0.0214)	-0.0845*** (0.0278)	0.0163 (0.0200)
Ln Natural resource	-0.0539 (0.0423)	-0.437*** (0.0808)	0.245** (0.0971)
Ln Employment in Agriculture	-0.638*** (0.165)	-0.102 (0.216)	-0.785*** (0.152)
Ln Emploi in Services	0.003*** (0.168)	0.660*** (0.170)	0.308*** (0.544)
Ln Employment in Industry	-1.192*** (0.176)	-0.695*** (0.211)	-0.203 (0.359)
Ln self-Employment	0.0999** (0.0479)	-0.0406 (0.0547)	0.558*** (0.144)
Constant	927*** (1.083)	3.918*** (1.163)	-11.20*** (2.379)
Comments	442	216	218
R-squared	0.930	0.975	0.936

Standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1.

Table 5: Oster test (2019)

	(1) Controlled effect	2) Identified set
	$\hat{\beta}$ (S.E)	$[\hat{\beta} \beta^*(\min \{1, 1.3\hat{R}^2\}, \delta = 1]$
Panel A: Total sample	0.125*(0.0715)	
Innovation	444	[-0.753;0.125]
Obs	0.699	
R ²		
Panel B: High urbanization	-0.188(0.137)	
Innovation	218	[-0.188;-1.709]
Obs	0.760	

R^2

Panel C: Low	0.228*** (0.0676)	
urbanization	216	[0.0162; 0.228]
Innovation	0.787	
Obs		
R^2		

Note: The results in column (1) are reproduced from Tables 2 and 3. Standard errors are reported in parentheses.

*, ** indicates significance at the 10% and 5% level.

However, Oster points out that the value of the R^2 should also be taken into account, as the coefficients may remain stable after the addition of insignificant control variables, which does not necessarily mean the absence of omitted variable bias. Oster's approach allows us to see the biases of the omitted variables, thus identifying variables that help stabilize the coefficients of the fixed effects model. We therefore perform a boundary analysis of the multidimensional poverty indicators used in this study. Table 5 shows the range of β values from the full-control fixed-effects model. For ease of comparison, column (1) shows the controlled effect estimates for Tables 2 and 3. Boundary estimates are given in column (2) of Table 5. For the whole sample, the interval [-0.753; 0.125] includes zero, which means that there is no bias due to omitted variables. However, when the panel is divided in two, we observe that the intervals determined by Oster's method do not include zero, which implies that the fixed-effects estimates for these two panels are biased by the omitted variables. Thus, based on these results of the Oster test, we decide to introduce additional variables into our fixed-effect model in order to reduce the bias associated with the omitted variables. Among the different institutional variables, and in accordance with the principle of parsimony, we retain the efficiency of government and the control of corruption, taken from the World Bank's World Development Indicator database

Table 6: Robustness check: fixed effects with additional control variables

VARIABLES	All sample	Low urbanization	High urbanization
	Poverty	Poverty	Poverty
Innovation_index	0.168** (0.0643)	0.225*** (0.0682)	0.0172 (0.134)
Ln GDP	2.514*** (0.356)	1.654*** (0.396)	.819*** (0.961)
Ln FDI	0.0292**	-0.00726	0.0625**

	(0.0127)	(0.0149)	(0.0230)
Ln Natural resource	0.253***	0.212***	-0.270*
	(0.0710)	(0.0779)	(0.139)
Ln Employment in Agriculture	0.141	-0.331	-0.0839
	(0.254)	(0.304)	(0.613)
Ln Emploi in Services	0.571**	0.793***	-2.768
	(0.280)	(0.252)	(1.877)
Ln Employment in Industry	-0.0351	-0.228	0.435
	(0.268)	(0.273)	(0.796)
Ln self-Employment	0.139	0.126	0.199
	(0.119)	(0.115)	(0.325)
Effectiveness_	-0.670***	-0.284	-0.758*
	(0.201)	(0.249)	(0.397)
Corruption	0.759***	0.198	0.889***
	(0.152)	(0.229)	(0.235)
Constant	-20.52***	-12.25***	-26.73***
	(3.081)	(3.453)	(7.023)
Comments	444	216	228
Number of code	23	14	10
R-squared	0.772	0.794	0.831

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The results are presented in Table 6. One can observed that the introduction of the additional variables seems to significantly modify the coefficients of the parameters of the fixed effects model. Indeed, despite the fact that the Oster (2019) test did not detect the presence of the endogenous bias related to the omitted variables for the total sample, we find that the introduction of the institutional variables significantly increases the coefficient of the variable of interest, from 0.125 to 0.168. Similarly, for the panel of countries with a high rate of urbanisation, the coefficient of the variable of interest that was previously negative becomes positive, from -0.188 to 0.0172, even though this is not significant. For the panel of low urbanisation countries, we find that the introduction of the additional variables increases the coefficient of the variable of interest from 0.228 to 0.225. Overall, this result implies that, in addition to the control variables of the model, when the institutional variables are taken into account, technological innovations positively influence multidimensional poverty reduction, and specifically in large cities.

4.3.3. Mediation effect

Figure 6 is the result of the estimation of Figure 1 using the SmartPLS 4 software (Ringle et al., 2022). It appears that the technological innovation indicator negatively and significantly affects employment in the industrial sector, agriculture and self-employment at the 1% level. In turn, these three variables affect negatively and significantly at the 1% level the multidimensional poverty indicator. However, the path from technological innovation to multidimensional poverty through service sector employment does not appear to be significant. Therefore, this path is excluded as a transmission channel. It is then possible to identify the mediating variables and to argue that over the period studied, three channels amplified the technological innovations effect on multidimensional poverty reduction in SSA countries. This includes the level of employment in the industrial, agricultural and self-employed sectors. Indeed, these three types of employment represent good mediators between the adoption, adaptation and use of technological innovations and poverty reduction.

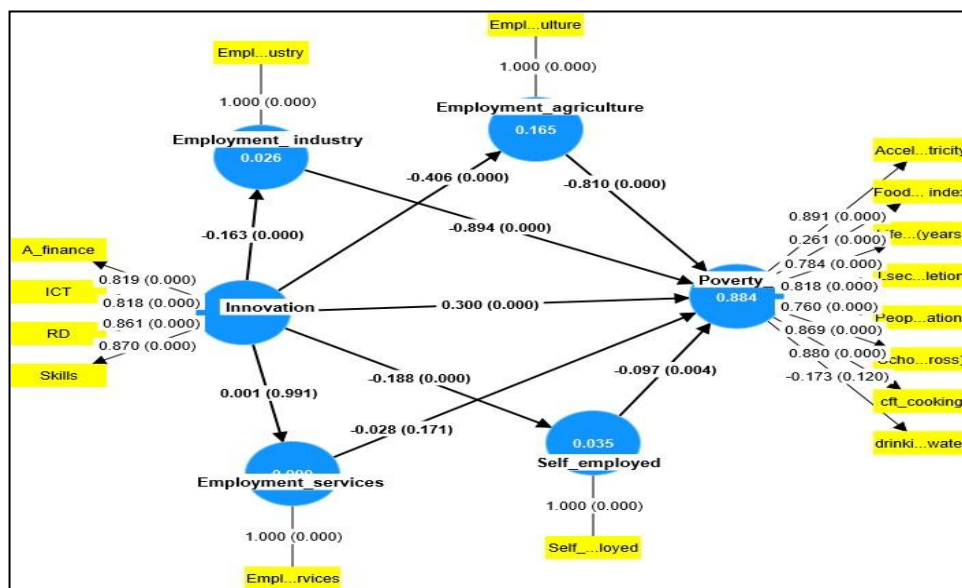


Table 7 therefore quantifies the mediating effects of the different types of employment in the relationship between technological innovations and poverty reduction. It appears that almost 30% of the total effect of the relationship between technological innovations on multidimensional poverty reduction is through total employment productivity in the industrial sector; 62.5% is through total employment productivity in the agricultural sector; and 31.4% is through productivity in the self-employment sector.

Table 7: Mediation effects

Variable	Indirect effect= $\varphi_1 \times \varphi_2$	Total effect= $\varphi_1 \times \varphi_2 + \varphi_3$	VAF=Indirect effect/Total effect
Employment_ industry	0,147	0,295	0,499
Employment_ agriculture	0,330	0,625	0,528
Self-employed	0,019	0,314	0,060

We also try to calculate the variation accounted for (VAF) to conclude the type of mediation. Indeed, the VAF determines the extent to which the mediation process explains the variance of the dependent variable. It is calculated as follows: $VAF = \text{Indirect effect} / \text{Total effect}$. As a general rule, if the VAF is less than 20%, it should be concluded that there is no mediation. On the other hand, a situation in which the VAF is higher than 20% and lower than 80% could be characterized as partial mediation; and a VAF higher than 80% indicates complete mediation (Hair et al., 2017). Thus, in the case of our study (Table 7), it appears that the VAF of employment in the industrial and agricultural sectors are between 20% and 80% respectively, which leads to the conclusion of partial mediation. On the other hand, the VAF in the self- employed sector is less than 20%, which leads to the conclusion that there is almost no mediation. These results imply that the essential mediation between technological innovations and poverty reduction is through employment productivity in the industrial and agricultural sectors respectively. However, the use of VAF as a determinant of the type of mediation is not without appeal in this research. Indeed, since the indirect effect of self-employment is significant, but does not mediate a large part of the total effect, it is not surprising that its VAF is low. Also, this low VAF may be due to the presence of multicollinearity between the different types of jobs. For example, self-employment jobs can be found in the agricultural sector and even in the industrial sector. Finally, we validated the hypothesis that, technological innovations contribute to poverty reduction in sub-Saharan Africa through the opportunity that they offer to create inclusive employment in the agricultural and industrial sectors, even if the result concluding that there is almost no medication in the self-employed sector must be put into perspective.

6. Conclusion and recommendations

This study was analyzed the effect of technological innovation on poverty reduction. Using different methodologies, we find that technological innovations positively and significantly influence poverty reduction in sub-Saharan Africa. The results survive several robustness tests. However, taking into account the level of urbanisation, it appears that technological innovations reduce poverty in low urbanisation countries and increase it in high urbanisation countries. Also, the analysis of mediation effects suggests that

about 30% of the total effect of technological innovations on multidimensional poverty reduction is through inclusive employment in the industrial sector, while 62.5% in the agricultural sector. Our study has important implications for researchers and policymakers.

Overall, our study is a first step towards identifying the link between innovation theory and poverty reduction by going beyond the Schumpeterian view of innovation as a driver of firm performance and an essential element of growth at the state level. Our study also transcends the conception of innovation as an element of spatial dynamics and territorial development, placing at the center of the approach the enhancement of the living conditions of marginalized populations. Therefore, inclusive development policies must ensure that a large number of people have access to technological innovation, to reach a higher level. These ideas allow us to bridge the gap between the literature on innovation and poverty reduction by highlighting the importance of acquiring technological, entrepreneurial skills and identifying strategies that enable people to benefit from the discovery and creation of opportunities from existing innovations.

Furthermore, our research has implications beyond the scientific framework. Indeed, the impact of technological innovations on the productivity of the industrial and agricultural sectors can influence the strategic orientation of inclusive development. However, it is important to take into account the urbanisation aspects. In fact, aspects of policy orientation and innovation diffusion are mutually reinforcing with the degree of urbanisation. This suggests that global policies for access to technological innovation will be effective in terms of increasing labour productivity in the industrial and agricultural sectors and reducing poverty, but local policies that take into account specific circumstances and the level of urbanisation will be more effective. Finally, our study shows that in a dynamic and highly competitive environment, human capital building activities and access to finance are essential to benefit from adaptive innovation in emerging markets. Governments should therefore focus on financial sector and human capital development as essential elements that, over time, can lead to the creation of new products and production processes, the opening of new markets and the creation of sustainable wealth.

References

- Acemoglu, D., & Robinson, J. (2013). *Why nations fail*. New York: Crown Publishers.
- Adeleye, N., & Eboagu, C. (2019). Evaluation of ICT development and economic growth in Africa. *NETNOMICS: Economic Research and Electronic Networking*, 20(1), 31-53.
- Aker, J. C., & Mbiti, I. M. (2010). Mobile phones and economic development in Africa. *Journal of economic Perspectives*, 24(3), 207-32.
- Alkire, S. (2005). *Valuing freedoms: Sen's capability approach and poverty reduction*. Oxford University Press on Demand.
- Appiah-Otoo, I., & Song, N. (2021). The impact of ICT on economic growth- Comparing rich and poor countries. *Telecommunications Policy*, 45(2), 102082.
- Asheim, B. T., Moodysson, J., & Tödtling, F. (2011). Constructing regional advantage: Towards state-of-the-art regional innovation system policies in Europe? *European Planning Studies*, 19(7), 1133-1139.
- Asongu, S. A., & Odhiambo, N. M. (2020). Foreign direct investment, information technology and economic growth dynamics in Sub-Saharan Africa. *Telecommunications Policy*, 44(1), 101838.
- Assefa, A., Waters-Bayer, A., Fincham, R., & Mudahara, M. (2009). Comparison of frameworks for studying grassroots innovation: Agricultural Innovation Systems (AIS) and Agricultural Knowledge and Information Systems (AKIS). In P. Sanginga, A. Waters- Bayer, S. Kaaria, J. Njuki, & C. Wettasinha (Eds.), *Innovation Africa: Enriching farmers livelihoods* (vol., pp. 35-56). London: Earthscan.
- Besley, T., & Burgess, R. (2003). Halving global poverty. *Journal of economic perspectives*, 17(3), 3-22.
- Bojnec, Š., & Fertő, I. (2012). Broadband availability and economic growth. *Industrial Management & Data Systems*.
- Burrus, R. T., Graham, J. E., & Jones, A. T. (2018). Regional innovation and firm performance. *Journal of Business Research*, 88, 357-362.
- Çalışkan, H. K. (2015). Technological change and economic growth. *Procedia-Social and Behavioral Sciences*, 195, 649-654.
- Cervantes-Godoy, D., & Dewbre, J. (2010). Economic importance of agriculture for poverty reduction.
- Chataway, J., Hanlin, R., & Kaplinsky, R. (2014). Inclusive innovation: an architecture for policy development. *Innovation and Development*, 4(1), 33-54.
- Churchill, S. A., & Farrell, L. (2017). Investigating the relationship between smoking and subjective welfare. *Journal of Behavioral and Experimental Economics*, 71, 1-12.
- Dewan, S., & Kraemer, K. (2000) Information technology and productivity: Evidence from country-level data. *Management Science*, 46(4), 548-562. <https://doi.org/10.1287/mnsc.46.4.548.12057>.
- Dosi, G., & Nelson, R. R. (2010). Technical change and industrial dynamics as evolutionary processes. *Handbook of the Economics of Innovation*, 1, 51-127.

- Doucet, H., & Duplantie, A. (2017). The capability approach: its contribution to care practices. *Ethics & Health*, 14(1), 11-18.
- Driscoll, J.C., & Kraay, A.C. (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Rev. Econ. Stat.* 80 (4), 549-560.
- Dyson, F. J., Hansma, P. K., Roof, W. C., & Proctor, J. D. (2001). Technology and social justice. UCTV, Instructional Resources, University of California.
- Egyir, J., Sakyi, D., & Baidoo, S. T. (2020). How does capital flows affect the impact of trade on economic growth in Africa?. *The Journal of International Trade & Economic Development*, 29(3), 353-372.
- Florida, R. (2002). The economic geography of talent. *Annals of the Association of American geographers*, 92(4), 743-755.
- Friis-Hansen, E., & Egelyng, H. (2007). Supporting local innovation for rural development: analysis and review of five innovation support funds.
- Galperin, H. (2005). Wireless Networks and Rural Development: Opportunities for Latin America. *Information Technologies and International Development*, 2(3), 47-56.
- Gordon, R. J. (2000). Does the 'new economy' measure up to the great inventions of the past? *Journal of economic perspectives*, 14(4), 49-74.
- Hair, J. F., Hult, T. M., Ringle, C. M., & Sarstedt, M. (2017). A primer on partial least square structural equation modeling (PLS-SEM). Sage Publications.
- Hassink, R., Cooke, P., Heidenreich, M., & Braczyk, H. (2004). Regional innovation support system in South Korea. *Regional Innovation Systems: The Role of Governance in a Globalized World*, 327-343.
- Heeks, R., Foster, C., & Nugroho, Y. (2014). New models of inclusive innovation for development. *Innovation and Development*, 4(2), 175-185.
- Hoffecker, E. (2018). Local Innovation: what it is and why it matters for developing economies.
- D-Lab Working Papers: NDIR Working Paper, 1.
- Hofman, A., Aravena, C., & Aliaga, V. (2016). Information and communication technologies and their impact in the economic growth of Latin America, 1990-2013. *Telecommunications Policy*, 40(5), 485-501.
- Horst, H., & Miller, D. (2005). From kinship to link-up: the cell phone and social networking in Jamaica, *Current Antropology*, 46, 755-778.
- Hosseini, S. M. P., & Narayanan, S. (2014). Adoption, adaptive innovation, and creative innovation among SMEs in Malaysian manufacturing. *Asian Economic Papers*, 13(2), 32- 58.
- Howitt, P. (2010). Endogenous growth theory. In *Economic growth* (pp. 68-73). Palgrave Macmillan, London.
- Howitt, P. (2010). Endogenous growth theory. In *Economic growth* (pp. 68-73). Palgrave Macmillan, London.
- Islam, R. (2004). The nexus of economic growth, employment and poverty reduction: An empirical analysis (Vol. 14). Geneva: Recovery and Reconstruction Department, International Labour Office.
- Jha, S. K., & Krishnan, R. T. (2013). Local innovation: The key to globalisation. *IIMB Management Review*, 25(4), 249-256.

- Judson, R.A., Owen, A.L., 1999. Estimating dynamic panel data models: a guide for macroeconomists. *Econ. Lett.* 65 (1), 9-15.
- Karner, J., & Onyeji, R. (2007). Telecom private investment and economic growth: the case of African and Central & East European countries. Jonkoping University.
- Klein, M. U., Aaron, C., & Hadjimichael, B. (2001). Foreign direct investment and poverty reduction (Vol. 2613). World Bank Publications.
- Klerkx, L., Aarts, N., & Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: The interactions between innovation networks and their environment. *Agricultural systems*, 103(6), 390-400.
- Kouladouma, J. C., Ngouhouo, I., & Miamo, C. W. (2023). Wellbeing in Africa: The role of technology transfer. *Technology in Society*, 102238.
- Kraay, A. (2006). When is growth pro-poor? Evidence from a panel of countries. *Journal of development economics*, 80(1), 198-227.
- Krugman, P., & Elizondo, R. L. (1996). Trade policy and the third world metropolis. *Journal of development economics*, 49(1), 137-150.
- Levidow, L., & Papaioannou, T. (2018). Which inclusive innovation? Competing normative assumptions around social justice. *Innovation and Development*, 8(2), 209-226.
- Lewbel, A., 2012. Using heteroscedasticity to identify and estimate mismeasured and endogenous regressor models. *J. Bus. Econ. Stat.* 30 (1), 67-80.
- Ling, R. (2008). *New Tech, New Ties: How Mobile Communication is Reshaping Social Cohesion*. Cambridge: MIT Press.
- Magombeyi, M. T., & Odhiambo, N. M. (2017). Foreign direct investment and poverty reduction. *Comparative Economic Research*, 20(2), 73-89.
- Maguain, D. (2002). Les théories de la justice distributive post-rawlsiennes: une revue de la littérature. *Revue économique*, 53(2), 165-199.
- McNamara, K. S. (2003). *Information and Communication Technologies, Poverty and Development: Learning from Experience*. Ginebra: The World Bank.
- Mendola, M. (2007). Agricultural technology adoption and poverty reduction: A propensity- score matching analysis for rural Bangladesh. *Food policy*, 32(3), 372-393.
- Mhula-Links, A., Hart, T., & Jacobs, P. (2014). Local is lekker: the relevance of local agricultural innovations in rural South Africa.
- Mittal, S., & Tripathi, G. (2009). Role of mobile phone technology in improving small farm productivity. *Agricultural Economics Research Review*, 22(347-2016-16874), 451-460.
- Myovella, G., Karacuka, M., & Haucap, J. (2020). Digitalization and economic growth: A comparative analysis of Sub-Saharan Africa and OECD economies. *Telecommunications Policy*, 44(2), 101856.
- Muller, C., & A. Trannoy. 2011. "A Dominance Approach to the Appraisal of the Distribution of Well-Being Across Countries." *Journal of Public Economics* 95: 239-246
- Niebel, T. (2018). ICT and economic growth-Comparing developing, emerging and developed countries. *World Development*, 104, 197-211.

- Odame, H. S., Okeyo-Owuor, J. B., Changeh, J. G., & Otieno, J. O. (2020). The role of technology in inclusive innovation of urban agriculture. *Current Opinion in Environmental Sustainability*, 43, 106-111.
- Oltra, V., Kemp, R., & de Vries, F. (2008). Patents as a measure for eco-innovation. Deliverable 9 of the MEI (Measuring eco-innovation) FP6 project.
- Osabohien, R., Matthew, O., Gershon, O., Ogunbiyi, T., & Nwosu, E. (2019). Agriculture development, employment generation and poverty reduction in West Africa. *The Open Agriculture Journal*, 13(1).
- Peña-Vinces, J. C., Cepeda-Carrión, G., & Chin, W. W. (2012). Effect of ITC on the international competitiveness of firms. *Management decision*.
- Ravallion, M., Chen, S., & Sangraula, P. (2007). New evidence on the urbanization of global poverty. *Population and development review*, 33(4), 667-701.
- Ringle, C. M., Wende, S., and Becker, J.-M. (2022). "SmartPLS 4." Oststeinbek: SmartPLS GmbH, <http://www.smartpls.com>.
- Rodrik, D. (2015). Premature deindustrialization. *Journal of Economic Growth*, 21(1), 1-33. <https://doi.org/10.1007/s10887-015-9122-3>.
- Rodrik, D. (2018). New technologies, global value chains, and developing economies. Pathways for Prosperity Commission Background Paper Series; no. 1 United Kingdom: Oxford.
- Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy*, 98(5, Part 2), S71-S102.
- Romer, P. M. (1994). The origins of endogenous growth. *Journal of Economic perspectives*, 8(1), 3-22.
- Samimi, J. A., Ledary, R. B., & Samimi, J. F. (2015). ICT & economic growth: A comparison between developed & developing countries. *International Journal of Liability and Scientific Enquiry*, 1, 26-32.
- Sarafidis, V., & Wansbeek, T. (2012). Cross-sectional dependence in panel data analysis. *Econometric Reviews*, 31(5), 483-531.
- Schumpeter, J. A. (1934). The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle.
- Sen, A. (1973). "On the Development of Basic Income Indicators to Supplement GNP Measures." *UN Economic Bulletin for Asia and the Far East* 24.
- Sen, A. (1974). "Informational Bases of Alternative Welfare Approaches: Aggregation and Income Distribution." *Journal of Public Economics* 3: 387-403.
- Sen, A. (1976). "Real National Income." *The Review of Economic Studies* 43: 19-39.
- Sen, A. 1985. *Commodities and Capabilities*. Oxford: Oxford University Press.
- Sen, A. (1992) *Inequality Reexamined*, Harvard University Press, Cambridge, Mass.
- Sen, A. (1999) *Development As Freedom*, Knopf Press, New York.
- Shearmur, R. (2012). Are cities the font of innovation? A critical review of the literature on cities and innovation. *Cities*, 29, S9-S18.
- Si, S., Ahlstrom, D., Wei, J., & Cullen, J. (2020). Business, entrepreneurship and innovation toward poverty reduction. *Entrepreneurship & Regional Development*, 32(1-2), 1-20.
- Smith, A. (1937). *The wealth of nations [1776]* (Vol. 11937). na.

- Solomon, E. M., & van Klyton, A. (2020). The impact of digital technology usage on economic growth in Africa. *Utilities policy*, 67, 101104.
- Venturini, S., & Mehmetoglu, M. (2019). plssem: A stata package for structural equation modeling with partial least squares. *Journal of statistical software*, 88, 1-35.
- Wendji, C. M., & Pilag Kakeu, C. B. (2022). The effect of external knowledge on innovation capacity of SMES: Does the source of knowledge matter?. *African Journal of Science, Technology, Innovation and Development*, 14(6), 1655-1666.
- World Bank (WB) (2015). Africa infrastructure country diagnostics (AICD). Retrieved from <http://web.worldbank.org/wbsite/external/topics/extinformation and technologies/0,contentmdk:21525984~pagepk:210058~pipk:210062~thesitepk:282823,00.html>.
- Santos, D. F. L., Basso, L. F. C., Kimura, H., & Kayo, E. K. (2014). Innovation efforts and performances of Brazilian firms. *Journal of Business Research*, 67(4), 527-535.
- Camisón, C., & Villar-López, A. (2014). Organizational innovation as an enabler of technological innovation capabilities and firm performance. *Journal of business research*, 67(1), 2891-2902.
- Gunday, G., Ulusoy, G., Kilic, K., & Alpkan, L. (2011). Effects of innovation types on firm performance. *International Journal of production economics*, 133(2), 662-676.
- Darroch, J. (2005). Knowledge management, innovation and firm performance. *Journal of knowledge management*, 9(3), 101-115.
- Khan, I., Khan, I., Sayal, A. U., & Khan, M. Z. (2022). Does financial inclusion induce poverty, income inequality, and financial stability: Empirical evidence from the 54 African countries?. *Journal of Economic Studies*, 49(2), 303-314.
- Kouadio, H. K., & Gakpa, L. L. (2022). Do economic growth and institutional quality reduce poverty and inequality in West Africa?. *Journal of Policy Modeling*, 44(1), 41-63.
- Pilag Kakeu, C. B., Dze Achuo, E., Kouhomou, C. Z., & Tonga Ndjakwa, M. (2021). Macroeconomic Convergence in the CEMAC Zone: Some Stylized Facts Using the Covid- 19 Yardstick. *Academia Letters*, 2.
- Rodríguez-Pose, A., & Tselios, V. (2019). Well-being, political decentralisation and governance quality in Europe. *Journal of Human Development and Capabilities*, 20(1), 69- 93.
- Gassmann, O., Enkel, E., & Chesbrough, H. (2010). The future of open innovation. *R&d Management*, 40(3), 213-221.
- West, J., Vanhaverbeke, W., & Chesbrough, H. (2006). Open innovation: a research agenda. *Open innovation: Researching a new paradigm*, 17(4), 285-307.
- Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative science quarterly*, 128-152.

- Chesbrough, H. W. (2003). Open innovation: The new imperative for creating and profiting from technology. Harvard Business Press.
- Nelson, R. R., & Winter, S. G. (1982). The Schumpeterian tradeoff revisited. *The American economic review*, 72(1), 114-132.

Notes

¹ Defined as all countries whose innovation indexes are at least 10% higher than would be expected given their level of GDP (around USD 2,000 in PPP terms).

² *Global Innovation Index 2022: What is the future of innovation-driven growth? (wipo.int)

Menstrual health, grassroots innovations and social entrepreneurship: Exploring the case of Indian “Pad Man”

Kajal Kumari, Hemant Kumar

Central University of Gujarat, Gandhinagar, India

Abstract

Numerous societies have cultural and religious taboos, myths, and misunderstandings concerning menstruation, menstruators, menstrual hygiene, and the management of these issues. Despite the fact that menstruation is evidence that a person's reproductive health is in order and precautions must be taken to avoid health problems during this time. Menstruators in countries of the global south, such as India, often lack access to fundamental menstrual hygiene products. This paper identifies challenges that menstruators face during menstruation, provides a comparative analysis of various menstrual products to encourage the use of the most sustainable practices and reduce the risk of infection and other health problems, and breaks the taboo surrounding the topic. Additionally, it employs an exploratory approach, utilising a case study analysis of Self Help Groups within the context of social entrepreneurship where a grassroots innovation has been implemented for sustainable production and practises related to menstruation. Results suggest that there are numerous challenges faced by SHGs in implementing and running the sanitary pads production unit due to social taboos, lack of infrastructure, and other support systems from the formal sector in the region. The study's distinctiveness is rooted in the selected framework, which examines the intersection of social entrepreneurship and grassroots innovation in diffusion of commercialisation of innovations from the informal sector. It also highlights the challenges faced by the grassroots innovations during the process of diffusion and commercialisation. Further, it suggests a few social and policy implications of this research

Key Words: Grassroots innovations, menstrual hygiene, period poverty, social entrepreneurship, India

1. Introduction

The onset of menstruation is an inherent biological occurrence that is accompanied by enduring societal stigmatization for individuals who reach puberty and experience this process. The phenomenon is observed in individuals with regular menstrual cycles and is considered a significant factor in determining their reproductive capacity. The onset of menarche, or the first menstrual period, displays variability based on factors such as the health status, ethnicity, geographical location, and other individual characteristics of the menstruating individual. Typically, the onset of menarche occurs within the age range of 8 to 16 years, while menopause, signifying the cessation of menstruation, occurs at an average age of 50. This statement illustrates the duration of menstruation that a person who menstruates may experience throughout their lifetime, which amounts to approximately 3.836 years (or four years). Menstruation is a natural biological process that requires menstruators to exercise additional hygiene measures during their menstrual cycle to safeguard their overall health and reproductive well-being. A significant concern pertains to the potential for infection resulting from bacterial proliferation, which can result in the development of bacterial vaginosis or Urinary Tract Infection (UTIs) (Mayo Clinic Staff, 2021). Maintaining regular intervals for changing menstrual products and ensuring cleanliness and freshness of the genital area are crucial steps in addressing this issue. Tampons and sanitary napkins have been found to cause skin irritation, which is a notable concern (Centre for Disease Control and Prevention, 2020). However, there exist underlying factors that contribute to the phenomenon of period poverty. In India, a significant number of menstruators are unable to procure menstrual products such as sanitary napkins and tampons due to financial constraints. Consequently, they resort to utilizing alternative materials such as rags, leaves, and ashes. The absence of hygienic water sources and sanitation amenities poses a challenge in upholding cleanliness. Insufficient education on menstrual hygiene persists due to cultural taboos and associated stigmatization. Menstruators frequently encounter discrimination, and their fundamental menstrual requirements are often disregarded due to gender inequality and poverty (Aparna, 2019). The aforementioned factors contribute to the prevalence of acute period poverty in India, exacerbating the situation, particularly in rural regions. This scenario may not be different in other low-and-medium income countries.

Lack of access to sanitary facilities, education, and menstruation products is referred to as "period poverty." Millions of girls and women around the world are impacted by this crucial issue, particularly in low-income nations. Over 500 million girls and women globally do not have access to basic menstrual hygiene facilities, which can have serious health repercussions, according to research by UNESCO (2020). Due to a lack of access to menstruation products and proper sanitation facilities, the issue is particularly serious in the Global South, where

up to 50% of girls miss school during their periods (Sommer et al., 2015). According to Dasgupta et al. (2018), approximately 23 million Indian girls drop out of school each year as a result of period poverty. In addition, menstrual hygiene education and awareness are lacking in many Global South nations due to the stigma associated with menstruation (Sommer et al., 2015). Due to this lack of education, unclean materials like rags or leaves are frequently used, which can result in infections and other health issues (UNESCO, 2020). To address this pressing issue, a number of initiatives have been launched to help girls and women in the Global South access menstrual hygiene products and education. Additionally, grassroots initiatives aimed at promoting social entrepreneurship based on local culture and livelihood will be very beneficial for promoting menstrual hygiene management in a long-term way.

In this context, both formal and informal sector organizations have put in place a number of strategies to address the problems connected to period poverty. For instance, in India a grassroots innovation (GI) was developed by social entrepreneur and grassroots innovator Arunachalam Muruganantham aimed at providing customized sanitary pads to menstruators in various regions of India and beyond (Venugopal and Abhi, 2013; Bentley et al., 2016; Balakrishna, 2018). The innovator has implemented the social entrepreneurship framework to disseminate his innovation to local communities, encompassing both urban and rural areas. This has been achieved through the commercialization of the GIs to women Self Help Groups (SHGs). The aforementioned model seems quite successful at first glance, and for the innovator it is (Venugopal and Abhi, 2013; Bentley et al., 2016; Balakrishna, 2018). However, it is unknown what happens when SHGs employ this GI. Therefore, our main focus is to explore the ramifications that result from grassroots innovations being adopted by Self-Help Groups (SHGs).

The present paper has been partitioned into six distinct sections. The subsequent section delves into the topics of menstrual hygiene and period poverty in the global south with special reference to India. Moreover, the paper explores through the theoretical underpinnings of grassroots innovations and social entrepreneurship in section 3. Section 4 outlines the methodology employed in the study, while section 5 presents the findings and analysis derived from the case. Finally, the conclusion section presents the social and policy implications of this research.

2. Menstrual hygiene: Social taboo and economic impact

Approximately 49% of the population in India is individuals who do not identify as male. According to the National Family Health Survey-5 conducted between 2019-21, India has documented a gender ratio of roughly 1,020 females per 1000 males in the year 2021. For the first time, the gender ratio has shifted in favor of women rather than men. This portrays a majority of the populace experiencing menstruation at different intervals. In contrast to expectations, the issue of menstrual hygiene, which requires sufficient attention, is characterized

by inadequate awareness, accessibility, and affordability with regard to menstrual health and hygiene management. There exist numerous additional factors that contribute to the prominence of this particular natural occurrence. The stigma associated with menstruation and the lack of discourse surrounding it, coupled with challenges related to the accessibility and affordability of menstrual products, as well as the exclusivity of the market catering to specific classes and genders of menstruators, and a limited level of awareness regarding menstrual health, are all pertinent issues. However, thoughts and questions are perpetually centered on how do menstruators maintain menstrual hygiene? To what extent is menstrual hygiene a matter of concern among the population in question? What are the methods utilized by individuals who menstruate to uphold their menstrual health?

Responding to these questions leads to the unraveling of the various factors that impact menstrual health and the management of menstrual hygiene. Diverse approaches exist worldwide, including within India, for the management of menstruation. Menstruators in India employ diverse strategies to manage their menstrual cycles, which are influenced by factors such as ethnicity, region, religion, social and cultural norms, personal preferences, economic status, and parental influence. Menstrual hygiene practices encompass the utilization of unhygienic and outdated cloth by menstruators for the purpose of blood absorption. These garments are subsequently laundered and air-dried in discreet locations to prevent detection by other household members. According to Kaur's (2018) research, certain areas of India, such as Madurai (Tamil Nadu), Malappuram (Kerala), Badka Gaun (Motihari, Bihar), and Dharavi (Mumbai, Maharashtra), hold the belief that garments worn during menstruation are imbued with malevolent powers capable of performing black magic on men. The authors assert that menstrual fluid is often stigmatized as shameful, contaminating, and repulsive, with potential negative impacts on individuals' health and economic well-being as well as broader societal implications.

The natural occurrence of menstruation has been subject to various social taboos, resulting in its discussion being deemed taboo. Numerous societies possess cultural and religious taboos, myths, and misconceptions regarding blood, individuals who menstruate, menstrual hygiene, and the management thereof. In the Hindu religion, menstrual cycles are regarded as "impure". In Nepali culture, the Kumari Kanya, who are prepubescent girls, hold a revered status akin to that of a deity, specifically associated with Kali, the Hindu goddess. It is believed that upon reaching menarche and experiencing menstruation, they lose their sacred powers and are immediately stripped of their divine status. As a result, they must relinquish their position as a living embodiment of divinity. The Bible references a scenario in which menstruators may be subject to contamination or pollution during their menstrual cycle. In Jewish tradition, menstruating or bleeding females and any objects that come into contact with them are regarded as impure. In the Islamic faith, women who are menstruating are prohibited from handling the sacred Qur'an and engaging

in prayer for a minimum of three days and up to seven days. According to Kaur et al. (2018), there are various social, cultural, and religious restrictions that impede the effective management of menstrual hygiene, thereby perpetuating the challenges associated with menstruation and menstrual practices. Women face considerable challenges and obstacles in various settings, including their homes, classrooms, and workplaces. The rationale behind this is that individuals are often unprepared and lack awareness regarding their menstrual cycles in various regions of the nation. This article sheds light on the issues surrounding the accessibility and affordability of menstrual hygiene products, as well as the potential hazards associated with improper disposal and maintenance practices in India.

Various perspectives on the politics of menstrual hygiene are presented. From a gender perspective, it can be observed that the menstrual products available in the market lack inclusivity for all genders. These products are marketed and sold under the label of a single gender, namely "women." It is a commonly held societal perception that menstruation and womanhood are inherently interconnected. However, the reality is that this is not necessarily the case. It is worth noting that individuals who identify as trans men and non-binary may also experience menstrual cycles, while trans women may encounter symptoms similar to those associated with menstruation, but not necessarily the menstrual cycle itself. The second one pertains to an economic standpoint. The pricing of menstrual products suggests a notable tax burden on such items, commonly referred to as the "Pink Tax" (Rodriguez, 2022). The Goods and Services Tax (GST) implemented in India in July 2017 levied a 12 percent tax on sanitary pads. In 2018, the Indian government eliminated the Goods and Services Tax (GST) on menstrual hygiene products with the aim of enhancing affordability and accessibility of these products for menstruating individuals in India. A noteworthy measure was implemented in the context of demonstrations and initiatives carried out by entities dedicated to the management of menstrual hygiene in India (The Hindu, 2021). The serviette industry has consistently demonstrated its profitability due to its widespread use among consumers, resulting in a perpetual demand for the product.

The clientele of the business may undergo changes over time, however, the demand for menstrual hygiene products such as sanitary napkins remain constant. While some individuals may experience menopause, others may enter puberty and experience their first menstrual cycle (menarche). This suggests that the business has the potential to maintain success over its lifespan. The high demand for sanitary napkins during menstruation is attributed to their ability to provide both hygiene and comfort. The need to address the stigma surrounding menstruation is crucial in comprehending and tackling the obstacles that individuals encounter when attempting to obtain menstrual hygiene products. The phenomenon of period poverty is a tangible and pressing issue. Ensuring period equity should also be grounded in practicality. According to the findings of the National Family Health Survey, a significant

proportion of women in India, specifically 77.6%, exhibit a preference for utilizing various menstrual hygienic protection methods during their menstrual cycle. Among these methods, sanitary pads are the most commonly preferred option, with 64.4% of women indicating their preference for this product. However, a notable proportion of women, approximately 15%, still opt for local napkins as their preferred menstrual hygiene product. According to the findings of the National Family Health Survey-5 conducted between 2019-21, it was observed that Indian women exhibit a preference for using pads and cloth over other menstrual hygiene products. However, a challenge arises when societal misunderstandings or cultural restrictions hinder individuals from advocating for their own rights. If such stigmas are eliminated or if the discourse surrounding these matters is facilitated, it can significantly enhance a society's ability to cater to the requirements of its entire populace. The reproductive cycle, which is essential for human survival, imposes financial and physical hardships on half of the population, leading to a lack of justice. According to Goyal's (2016) postulation, there exist various challenges and opportunities that are associated with menstrual health products in India. The production of the product by micro enterprises is expected to result in a significant rise in its availability, thereby expanding the consumer base and ultimately increasing the market size in India. Furthermore, it reveals the varying extent of utilization of sanitary pads across diverse regions of India. The author posits that menstrual products are often classified as luxury items rather than essential goods. Additionally, the author advocates for the dissemination of information regarding the potential health risks associated with traditional practices such as the use of cloths and locally-made napkins, which may increase the likelihood of reproductive tract infections among menstruating individuals. Grassroots innovation may serve as a potential initiative to address and potentially resolve this issue.

The data suggests that a significant proportion of menstruating individuals in India face financial constraints in accessing menstrual products, as a considerable number of 63 million Indians are reportedly pushed into poverty annually due to healthcare expenses (Oxfam International, 2022). According to Sumpeter's (2013) assertion, women residing in lower income settings encounter considerable difficulties in managing menstruation. Nevertheless, the impact of inadequate menstrual hygiene management (MHM) remains uncertain. The potential impact of MHM on the reproductive tract is a subject of plausibility, however, the precise nature of the infections, the magnitude of the effect, and the mode of transmission, remain uncertain. There exists a dearth of high-quality randomized intervention studies that integrate hardware and software interventions, specifically aimed at comprehending the nuanced impact of enhancing menstrual hygiene management on girls' school attendance.

A diverse range of menstrual fluid absorbent products and period pain relieving products are available in the market, including but not limited to

sanitary pads, tampons, menstrual cups, menstrual discs, period panties, pain relievers, body heating devices, foam washes, and ongoing innovations (Table 1). However, in nations such as India, where over 50% of the populace belongs to the middle and lower socioeconomic strata, obtaining access to these aforementioned commodities appears to pose a challenge. Based on the data from 2019-2021, it can be observed that a proportion of 4.2% of the population, which accounts for 16.4% of the total, is living in a state of extreme poverty. This condition is characterized by a deprivation score exceeding 50%, which signifies the inadequate availability and affordability of menstrual hygiene products. The article by Kaur et al. (2018) provides an in-depth analysis of various menstrual products and their corresponding affordability range. Cloth pads that can be washed and reused. While menstrual cups may present a sustainable option for menstrual hygiene management, it is important to ensure that they are cleaned and dried in a hygienic manner, potentially through exposure to sunlight. Sun-drying clothes and cloth pads can serve as a natural disinfectant, effectively sterilizing them for subsequent use. The utilization of reusable cloth pads is cost-effective, conveniently obtainable, and ecologically advantageous. According to Kaur (2018), to avoid contamination, it is necessary to store them in a hygienic and moisture-free setting for subsequent utilization.

Table 1: A comparison of various menstrual hygiene products

Menstrual Products	Usage	Pros	Cons	Price in market
Menstrual Cups	Made of silicon rubber, folded and inserted in to vagina, remove and empty the content every 12 hours	Reusable, environment friendly, cost effective in the long run, can be worn up to 12 hours without needing to change	May take time to get used to, need to be cleanse and sanitize after each use	A range of 350 INR to 1000 INR is easily available in Indian market depending on the durability, material made, and environmental impact of the menstrual cup
Tampons	A cylindrical tissue like structure attached with astring, insert in vagina with an applicator or fingers, change every 4-6 hours	Easy to use, can be worn during physical activity, come in variety of absorbing capacities	May cause dryness and irritation, risk of toxic shock syndrome if not changed regularly	Regular tampons to organic tampons have a varied range of \$6.97 to \$9.99 in US market and it is not used in India as such

Sanitary Napkins	Stick one side of the pad to undies, change every 4-6 hours	Easy to use, no inserting process required, come in different sizes and absorbent capacities	Can be bulky and uncomfortable, can shift during physical activity, difficult to dispose, good quality pads may be expensive, not biodegradable	Low quality pads range from Rs. 5-15 for 10 pads, medium quality range from Rs. 30-80 for 10 pads, high quality costs around Rs. 100-150 for 8-10 pads
Period Underwear	Wear like regular underwear, change every 4-6 hours	Reusable, eco friendly, no insertion required, no issue of disposing	Good quality period undies can be costly, may not help in heavy flow days	Different brands and styles have a range from 500 INR - 2000 INR
Menstrual Disc	Insert in to vagina	Can be worn during sex, can hold more amount of blood than tampon or pad	Can be difficult to insert or remove, may be uncomfortable to some users	The range varies from 500 INR - 2500 INR depending on quality, brand, and durability
Traditional cloths	Wear with regular undies which will collect fluid	Reusable, eco friendly, no insertion required, no issue of disposing	More chance to leak, carry less blood, uncomfortable to do sports activity, need to wash rigorously, more chances of infection	Old rags from houses are used, so no particular cost is attached

Source: Authors compilation

Table 1 provides an overview of various menstrual products that are currently available in the market. The table includes information on the usage, benefits, ill effects, and price comparison of these products. The advantages and disadvantages of each menstrual hygiene product are contingent upon a variety of factors. Several novel menstrual products have been introduced in the contemporary market, however, their adoption remains limited due to various factors. Despite the current era, sanitary pads remain an unaffordable choice for

numerous menstruators. However, as per the 2019-20 National Family Health Survey (NFHS-5) report, the utilization of sanitary napkins has risen from 48.5% to 78.9% among females aged 15 to 24 years in India. The limited adoption of menstrual products such as tampons, menstrual cups, and menstrual discs in India can be attributed to insufficient education regarding these novel menstrual products. Given their recent introduction to the market, individuals residing in rural regions are largely uninformed about these products. Despite individuals' knowledge of these products, additional myths and taboos, such as concerns surrounding hymen rupture and the loss of virginity, become relevant factors. Even in contemporary times, individuals who menstruate continue to opt for traditional cloth or disposable menstrual pads during their menstrual cycle. A primary concern related to the utilization of cloth materials for menstrual management is the potential for inadequate hygiene. Insufficient cleaning and drying of cloth can result in the proliferation of bacteria and fungal infections, as noted by Sahoo et al. (2014). The utilization of sanitary napkins, the second most commonly employed menstrual hygiene product, raises several concerns, including the appropriate disposal of pads, their non-biodegradability, potential health risks such as increased susceptibility to infections, as well as issues pertaining to accessibility, affordability, and comfort. The cost of menstrual products in India is subject to variation based on factors such as the brand, quality, and composition of the product. The responsibility of researching various options and taking into account factors such as cost, comfort, and environmental impact prior to making a purchase lies with the consumer.

In light of the various factors and obstacles that impede the utilization of menstrual products in India, social entrepreneurs have established a foundation to address several of these circumstances. Dees (2001) posits that social entrepreneurs function as agents of change within the social sector by embracing a mission to establish and maintain social value, rather than solely private value. They identify and actively pursue novel opportunities to serve this mission, while engaging in a continuous process of innovation, adaptation, and learning. These entrepreneurs demonstrate bold action, unencumbered by current resource limitations, and exhibit a heightened sense of accountability to the constituencies they serve and the outcomes they generate. Dees (2001). Social entrepreneurs typically address prevailing challenges by pinpointing the underlying cause of the issue and devising inventive remedies that are both enduring and expandable. Social entrepreneurs can be considered as grassroots innovators who exhibit their resourcefulness and creativity at the local level. According to Sengers and Wieczorek's publication, grassroots innovators are persons who utilize a bottom-up approach to create and execute innovative solutions to address local issues. According to Sengers et al. (2019), individuals frequently engage in cooperative efforts with their respective communities to recognise and resolve the underlying factors contributing to social and environmental issues.

3. Grassroots innovations and social entrepreneurship: combating societal misery

The concept of Grassroots Innovations (GI) has gained significant importance in the past few decades. It is founded on the principle of finding solutions through the involvement of the grassroots, as opposed to external sources (Gupta, 2016). According to Bhaduri and Kumar (2011), the utilization of GI presents a prospective strategy in tackling intricate predicaments encountered by societies globally. Grassroot innovation has the potential to stimulate creativity, resourcefulness, and entrepreneurship by enabling communities to independently identify and address their own challenges. Although there exist certain obstacles in achieving the full potential of grassroots innovation, it is imperative for policymakers and development practitioners to actively facilitate and endorse this methodology. It is defined as an innovative product or process created at the bottom of the pyramid, usually due to necessity, hardship and challenges (Hilmi, 2012). According to Kumar and Bhaduri (2014), individuals who lack access to formal education or resources often generate intricate solutions and cultivate innovative ideas. The implementation of a particular approach aimed at addressing the various challenges related to societal, financial, and ecological matters encountered by global communities. The limitations of organized methods of innovation have led to the emergence of the concept of grassroots innovation. The concept of grassroots innovation involves empowering communities with the necessary resources and knowledge to identify and address their own challenges through self-initiated solutions. According to Schot and Steinmuller (2018), the implementation of this approach fosters creativity, resourcefulness, and business acumen, leading to outcomes that are both sustainable and equitable. Grassroots innovation holds significant implications for individuals engaged in development and policy. According to Sharma and Kumar (2019), policymakers have the ability to promote development processes that are both inclusive and sustainable by endorsing innovation methods that originate from the grassroots level. Moreover, it has been suggested that grassroots innovation has the potential to enhance a community's resilience against external disruptions such as natural disasters and economic recessions (Lema et al., 2018). The potential of grassroots innovation is often impeded by financial and assistance constraints, as well as institutional and regulatory obstacles (Schot & Steinmuller, 2018). Moreover, the dissemination or expansion of GIs to a wider audience has proven to be a difficult task (Sharma and Kumar, 2019). Differential models have been utilized in multiple endeavors to establish commercial viability for GIs. Moreover, employing identical criteria to evaluate the expansion of informal enterprises as those utilized in the formal sector would not be advisable. Several instances of successful implementation of social entrepreneurship principles can be found, wherein GIs have been commercialized (Venugopal and Abhi, 2013; Bentley et al., 2016). The authors have reported on the commercialization of a sanitary napkin manufacturing device by a grassroots innovator, which has been classified as a social

enterprise. Therefore, comprehending the phenomenon of social entrepreneurship holds significant importance.

Social entrepreneurship is a growing field of study that focuses on using entrepreneurial skills and strategy to address social and environmental challenges. It has received considerable attention from scholars, policymakers, and practitioners over the past two decades. The Entrepreneurial Opportunity Identification and Exploitation (EOIE) framework was proposed by Johanna Mair and Ignasi Marti in 2006. The framework is based on the premise that entrepreneurs identify and exploit opportunities that arise from changes in the environment. The framework provides a structured approach to understand the complex process of opportunity identification and exploitation in entrepreneurial ventures. This framework consists of 4 key elements. The entrepreneurial actor, the environment, the opportunity, and the entrepreneurial process. The entrepreneurial actor is the person or group of people who identify and exploit the opportunity. The environment refers to external factors that influence opportunity such as, economic, social, cultural, and technological factors. The opportunity is the idea or the concept that is identified and exploited by the entrepreneur. The entrepreneurial process is the set of activities that the entrepreneur undertakes to turn the opportunity into a viable business venture (Mair and Marti, 2006).

Social entrepreneurship is defined as the pursuit of social and or environmental objectives through the creation of sustainable and innovative ideas (Dees, 2001). The primary objective of social entrepreneurship is to address societal problems such as poverty, inequality, and environmental degradation by creating self-sustaining businesses that generate positive social or environmental outcomes. There are many such examples like Barefoot College that was established in 1972 to promote rural development and empower women in India. The organization provides education and training programs to rural women on a range of topics, including solar engineering, water management, and healthcare. They mainly focus on capacity building to solve local problems using local resources (Roy & Tandon, 2018). Another example is SELCO Solar Energy is a social enterprise that was founded in 1995 to provide affordable solar energy solutions to rural communities in India. The organization works closely with local communities to identify their energy needs and develop solutions that are both affordable and sustainable. SELCO's approach is based on the principle of "design for the poor" and involves developing solutions that are simple, affordable, and easy to maintain (Balachandran & Kumari, 2017). Within this context, it can be argued that women's self-help groups (SHGs) possess the capacity to function as a form of social entrepreneurship. This is due to the fact that their involvement in such groups can lead to an improvement in their social status, as well as the well-being of their families and communities (Bonny and Rajendran, 2013; Yadav, 2021). Furthermore, it is possible that the benefits of women's SHGs may extend beyond the individual and community level, and contribute to broader societal gains (Haugh and Talwar, 2016).

Overall, social entrepreneurship can play a significant role in addressing social problems and is a powerful tool in promoting grassroots innovations. By working closely with communities and developing solutions that are embroidered for specific contexts, social entrepreneurship along with grassroots innovation plays a life and livelihood saving role. Coming up is the discussion on the methodology used to carry out the study on menstrual health through the frame of social entrepreneurship, and a grassroots innovation case study of pad man in India.

4. Selection of cases

The current research is of an exploratory nature and has employed a case study analysis approach. This approach involves a thorough analysis of a subject matter, presenting it in an objective manner (Yin, 2017). Additionally, it is employed to investigate a topic that lacks clear definition. The study employs a primary research methodology of conducting interviews, which is complemented by pre-existing interviews available on social media platforms. The research is conducted within the context of social entrepreneurship, utilizing a case study approach to examine the experiences of Muruganantham. The purpose of this investigation is to gain a more comprehensive understanding of the issue at the grassroots level. Muruganantham, recognised as the "padman" of India, embarked on a mission to effect change after observing his wife's use of outdated rags during menstruation, which was due to financial constraints that prevented her from purchasing sanitary napkins (Venugopal and Abhi, 2013; Bentley et al., 2016). One of the authors worked jointly with an innovator to establish two sanitary napkin production facilities in the Khatima, Udham Singh Nagar and Devprayag districts of Uttarakhand, in conjunction with Aakar Innovations and a group of students from a management college located in Noida.

Aakar Innovations laid the foundation for the project and opted to involve women Self-Help Groups (SHGs) in the operation of the units. On the day preceding the inauguration, all members of the team convened in Rudrapur, and female individuals were extended an invitation to establish a Self-Help Group (SHG). The innovator personally assembled all machine components in the presence of female individuals, with the intention of facilitating their comprehension and utilization of said machinery. The innovator provided a comprehensive guide outlining the sequential procedures for assembling the machine, demonstrating the process for producing napkins, sanitizing and packaging them. In addition, female participants were instructed on marketing and bookkeeping for group-led units by graduates of management programmes. The identical approach was implemented for the unit located in Haridwar. This facilitated a close observation of the operational dynamics of female personnel within the units. Subsequently, we were involved in providing the units with the necessary raw materials for their manufacturing processes. This facilitated our engagement with all relevant actors involved in the production and distribution of sanitary napkin pads. This encompasses

engagement with female Self-Help Group members, medical professionals, members of the press, student volunteers, and the individual who facilitated the allocation of space for these facilities.

5. Grassroots innovator meeting social entrepreneurs

Muruganantham embarked on a mission to develop an affordable machine for producing sanitary napkins. During the course of his endeavor, he was initially labeled as a "madman," but eventually earned the moniker of "padman" due to his triumphs (Balakrishnan, 2018). According to Padman's statements in various interviews, the machine in question is purportedly the first of its kind, designed to produce personalized sanitary pads. The product is intended to be accessible to individuals with limited formal education. The invention produced by the individual in question had a significant impact, resulting in discussions among individuals residing in rural areas regarding the subject matter, thereby breaking the taboo associated with it. The invention also facilitated employment opportunities for rural women and led to the adoption of sanitary napkins, replacing the use of traditional rags (TEDx Talks, 2013). The aforementioned achievement has solidified the notion that Muruganantham has effectively established himself as a successful social entrepreneur, as indicated by Venugopal and Abhi (2013) and Bentley et al. (2016). The innovator has received assistance from a range of governmental and non-governmental entities, including the National Innovation Foundation (NIF), in the dissemination of his innovation and safety certification for his products. Furthermore, he is demonstrating personal initiative in advancing the development of his innovative idea. We have participated along with the innovator in a meeting with a non-governmental organization (NGO) in Delhi to diffuse his innovation. Undoubtedly, the innovator has demonstrated prowess as an innovator by effectively commercializing his innovation through various channels and networks, both domestically and internationally, especially in low-income countries. Nonetheless, our attention extends beyond the aforementioned point, as we aim to investigate the outcomes of the diffusion and commercialisation of sanitary napkin making machines to their ultimate beneficiaries, i.e. women self-help groups.

Given the context, it was regarded appropriate to form a SHG for women, as the issue at hand was closely related to this demographic. The multifaceted nature of educating women in rural areas on the usage of sanitary pads lies in its ability to not only increase their knowledge on the subject matter, but also empower them to participate in the production of sanitary pads, leading to potential income generation. Moreover, it will facilitate their acquisition of competencies in the production and management of business organizations. During the inaugural event, medical professionals engaged in discussions regarding the necessity of sanitary pads and related concerns. Subsequently, a session of questioning and answering was conducted with female participants. Many of them brought up important issues like what should they do while menstruating? issues with access and affordability of sanitary pads, particularly

for girls in schools, beliefs and practices surrounding menstruation, and so forth. The comprehensive discourse facilitated an understanding of menstrual hygiene practices and dispelled several misconceptions pertaining to menstruation. This helped women participants to understand the need of menstrual hygiene practices and also usefulness of SHGs in menstrual hygiene practices.

As a result, SHG formation was started in two distinct locations. The fact that the women in these SHGs were from the same area and were well acquainted with one another was an advantage. However, the majority of them lacked a higher level of formal education. It was at this point that the management student's training in project and operation management proved beneficial. Aakar innovations, a social enterprise, moreover consented to give them guidance for six months in keeping their financial and other records. The Akar innovations team also assisted them in choosing the product's name, packaging design, cost estimation, and marketing strategies. It is obvious that Akar Innovations would also sustain itself if these units would operate successfully. Therefore, when they accepted to join the production team, roles were assigned to them. Some of them made the suggestion that they would engage in marketing because the nature of their current profession requires them to travel to various locations nearby. The SHG members were asked for their agreement for each action after discussing it with them first. Until this everything was fine. We also visited the Haridwar production unit center where the same mechanism was adopted to set up the unit.

After a period of six months, we revisited the units to assess their operational status. It has been discovered that these units are currently not operational. Additional investigation into the obstacles encountered by Self-Help Groups (SHGs) indicates that these practices are not bolstered by the current socio-economic conditions in said regions. The exclusive source of raw materials for the production of pads is limited to the innovator situated in Tamil Nadu, located in the southern region. The conveyance of voluminous raw material poses a significant challenge. At the outset of the project, our team was tasked with managing transportation logistics. Specifically, we were responsible for receiving raw materials from a courier agency in New Delhi, as the innovator had encountered difficulty in finding a courier partner capable of delivering directly to Uttarakhand. The transportation of the heavy consignment posed a significant challenge, which included the loading and unloading processes. Moreover, as a business commodity, taxes were required to be paid at the Delhi border. Additionally, there was an instance where a bribe had to be given to the policemen who were not allowing the team to load it onto the buses destined for these locations. Moreover, in cases where the units necessitate raw materials promptly, there may be a delay in the delivery of said materials to the designated locations and that too facing the above challenges time and again.

The second challenge pertained to the adequacy of infrastructure facilities in said regions. The production process necessitates the use of electricity to power

the machines. Electricity is accessible for a limited duration, specifically during a 2-3 hour window in the morning and another 2-3 hour window in the evening. This policy restricts the duration of labor performed by female employees within said units. During this period, a significant number of women were primarily engaged in domestic duties, including caring for their families and children. Employees can only report to work at those units once they are no longer confined to their homes. However, at that point in time, the availability of electricity was absent. This constituted a significant obstacle in the functioning of these entities. Moreover, in mountainous areas, the establishment of road networks posed a significant obstacle, particularly in the rainy season. The inclement weather conditions have resulted in the impairment of several roadways, hindering the ability of women to access remote areas and subsequently impacting the distribution of manufactured sanitary pads. The third challenge arose from familial attitudes towards menstruation, which are often stigmatized, which have been discussed earlier. A significant number of men expressed discomfort with the idea of their female counterparts working in such units, as it was deemed an occupation lacking in social prestige. Therefore, they fought with women over this issue, causing some of them to stop coming to work. This had a negative impact on the production process, as other workers were reaching but were seated idle. In addition, those who had been trained by Aakar innovations on how to maintain their records had left the group, and new members were unaware of how to do so. This ultimately led to an unsustainable business, and both units had to be shut down. This was the reason that Aakar Innovations also withdrew from the projects as they were not able to sustain. An executive from Aakar Innovations suggested that such a business model is not feasible for social enterprises like us. Now, they are working on production of menstrual hygiene products and they have made some innovations like bio-compostable raw materials, semi and fully automated machines and locations where infrastructures like electricity and connectivity is not an issue.

Thus, we could contend that the innovator's endeavor was successful, given that he is selling his innovation nationally and internationally. Additionally, his business plan appears sound on paper. The users of these devices, however, are unable to reap the benefits due to numerous obstacles posed by regional socio-economic and geographical conditions. Aakar Innovations has modified its business strategy by relocating its operations from rural to urban areas with adequate infrastructure and has also introduced novel approaches to raw materials, based on insights gained from prior experiences. Recent research has indicated that the use of sanitary pads may not be entirely safe due to a number of factors. The challenges associated with menstrual hygiene and the pivotal role played by grassroots innovators and social entrepreneurs cannot be ignored particularly in countries where inadequate information, income, and social stigmas have posed significant barriers in addressing the issue of period poverty. At the same time, one size fits all approach might not be helpful. Nonetheless, it may be necessary to develop additional innovative

methodologies and practices to surmount these obstacles. As suggested by Sharma and Kumar (2020), the venture capitalist model may be of some use in the commercialization of GIs. This may necessitate the participation of more social entrepreneurs and a prolonged duration of their involvement in the process. When GIs from the informal sector meet with institutions from the formal sector, this is even more crucial. Such assumptions require them to adhere to the norms of the formal sector, and they must do so. In order to improve the adaptability of GIs, it is necessary to introduce changes to the formal sector's norms.

6. Conclusion

The present study aimed to investigate the prevalence of myths and taboos surrounding a natural biological phenomenon, namely menstruation, and their impact on healthy menstrual practices. The present study facilitated comprehension of the function of social entrepreneurs in tackling menstrual hygiene issues at the grassroots level. The study facilitated the identification of the determinants that facilitate and impede social entrepreneurship within this particular context, as well as the tactics employed by grassroots innovators to effectuate a social influence. The Self- Help Groups (SHGs) facilitated an increased awareness and comprehension among menstruating participants regarding the significance of menstrual hygiene management, as well as the utility of SHGs in promoting effective menstrual hygiene practices. After a period of six months, it was discovered that the units intended for the manufacture of pads were not operational. The initiative aimed at restricting the scope of study encountered several obstacles. Firstly, the sole source of raw materials was located in Tamil Nadu, posing a significant challenge in transporting the bulky materials to Uttarakhand. Secondly, a considerable number of men expressed reservations about the prospect of women working in such units, as it was perceived as a profession lacking in social status. Additionally, the limited availability of electricity further compounded the issue.

Although this study has certain limitations, such as concentrating only on two unsuccessful SHGs, it can still have significant policy implications. By providing evidence-based information, this research can inform policy decisions related to menstrual hygiene management. The aforementioned can facilitate the formulation of policies and initiatives that endorse the establishment and execution of inventive and enduring measures for the management of menstrual hygiene at the community level. Undoubtedly, this requires support from formal sector stakeholders and institutions, but it must be done with careful consideration. The study has the potential to enhance the well-being of women and girls in the community by advocating for improved menstrual hygiene practices and mitigating the likelihood of infections and other health complications, thereby highlighting its social implications. The provision of information and resources to enable women to make informed decisions about their health and wellbeing can also serve as a means of

promoting women's empowerment. The study may potentially yield economic ramifications through the establishment of fresh employment prospects and revenue-generating endeavours for women. The concept of social entrepreneurship entails the establishment of enterprises that aim to tackle social issues and generate social benefits. By conducting research on menstrual hygiene within the framework of social entrepreneurship, it is possible to foster the emergence of such enterprises, thereby opening up fresh avenues for women to earn a livelihood and provide for themselves and their dependents.

Conducting a study on menstrual hygiene at the grassroots level holds significant potential for promoting grassroots innovation. This potential stems from the study's ability to identify specific needs and challenges, break down cultural taboos, empower women and girls, and create new job opportunities. The incorporation of social entrepreneurship framework in the study of menstruation can potentially enhance grassroots innovation through the creation of novel solutions, generation of employment prospects, dissemination of knowledge, and advocacy for societal transformation. Hence, it is plausible that systems of innovation and actor network theory (ANT) could serve as viable analytical frameworks for a deeper examination of instances where social entrepreneurship and grassroots innovations may intersect.

References

- Aparna, P. (2019). Period Poverty in India: Causes, effects and Solutions. *International Journal of Community Medicine and Public Health*, 6(10), 4359-4362. doi:10.18203/2394-6040.ijcpmh20194768
- Balachandran, S., & Kumari, V. (2017). Solar energy for the poor: the case of SELCO India. *Journal of Social Entrepreneurship*, 8(2), 163-178.
- Balakrishnan, R. (Director). (2018). *Pad Man* [Film]. Columbia Pictures, SPE Films India, Hope Productions, KriArj Entertainment and Mrs Funnybones Movies
- Bentley, C., Brombosz, V., Gabrielli, S., Lee, G.E., Nafade, V., Steele, L., and Wali, M. (2016). Taming the tide: Stories from India. *McGill Journal of Global Health*. 22-32. <https://mghjournal.com/wp-content/uploads/2016/08/taming-the-tide-2016.pdf> [Accessed on 15-04-2023]
- Bhaduri, S. and Kumar, H. (2011). Extrinsic and intrinsic motivations to innovate: tracing the motivation of 'grassroot' innovators in India. *Mind & Society* 10(1), 27-55. DOI: 10.1007/s11299-010-0081-2.
- Bonny, B.P. and Rajendran, P. (2013). Evaluation of Self Help Groups (SHG) as a social enterprise for women empowerment. *Journal of Tropical Agriculture*, 51 (1-2) : 60-65.
- Carinne Brody, Thomas de Hoop, Martina Vojtkova, Ruby Warnock, Megan Dunbar, Padmini Murthy & Shari L. Dworkin (2016): Can self-help group programs improve women's empowerment? A systematic review, *Journal of Development Effectiveness*, DOI:10.1080/19439342.2016.1206607
- Centers for Disease Control and Prevention. (2020). Menstrual Hygiene. CDC. <https://www.cdc.gov/healthywater/hygiene/healthyhabits/menstrual-hygiene.html>
- Chot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, 47(9), 1554-1567.
- Dasgupta, A., Sarkar, M., & Menon, N. (2018). Menstrual hygiene: How hygienic is the adolescent girl? *Indian Journal of Community Medicine*, 43(2), 86-88. https://doi.org/10.4103/ijcm.IJCM_274_16
- Dees, J. G. (2001). The meaning of "social entrepreneurship". Retrieved from https://ssir.org/articles/entry/the_meaning_of_social_entrepreneurship
- Dees, J. G. (2001). The meaning of social entrepreneurship. *Stanford Social Innovation Review*, 1(1), 1-8.
- Desai, S. J. (2020, June 14). Yes, some men bleed: Why JK Rowling is wrong that only women get periods. *The Times of India*. <https://timesofindia.indiatimes.com/home/sunday-times/yes-some-men-bleed-why-jk-rowling-is-wrong-that-only-women-get-periods/articleshow/76363810.cms>
- Goyal, V. (2016). Scope and opportunities for menstrual health and hygiene products in India. *International Research Journal of Social Sciences*, 5(7), 18-21.
- Haugh, H.M. and Talwar, A. (2016). Linking Social Entrepreneurship and Social Change: The Mediating Role of Empowerment. *Journal of Business Ethics*, 133, 643-658. <https://doi.org/10.1007/s10551-014-2449-4>

- Hilmi, M. R. (2012). Grassroots Innovation from the Bottom of the Pyramid. *Current Opinion in Creativity, Innovation and Entrepreneurship*, 1(2).
<https://doi.org/10.11565/cuocient.v1i2.5>
- India: gender ratio women to men by area 2021 | Statista. (n.d.). Statista.
<https://www.statista.com/statistics/1303286/india-urban-and-rural-gender-ratio/> inequality | Oxfam International.(n.d.). Oxfam International.
<https://www.oxfam.org/en/tags/inequality#:~:text=The%20richest%20%20percent%20grabbed,half%20of%20all%20new%20wealth.>
- Kaur, R., Kaur, K., & Kaur, R. (2018). Menstrual hygiene, management, and waste disposal: Practices and challenges faced by Girls/women of Developing countries . *Journal of environmental and public health* , 1-9. Retrieved February 27, 2023, from <https://doi.org/10.1155/2018/1730964>
- Kumar, H. and Bhaduri, S. (2014). Jugaad to grassroot innovations: Understanding the landscape of the informal sector innovations in India. *African Journal of Science, Technology, Innovation and Development*. 6(1). 13-22. DOI: 10.1080/20421338.2014.895481.
- Lema, R., Quadros, R., & Schot, J (2018). Grassroots innovation movements: challenges and contributions. *Innovation: Management, Policy & Practice*, 20(2), 133-142
- Mair, J., & Marti, I. (2006). Social Entrepreneurship Research: A Source of Explanation, prediction, and delight. *Journal world Business*,41(1), 36-44.
- Mayo Clinic Staff. (2021).Urinary Tract Infection (UTI).
 Mayo Clinic. <https://www.mayoclinic.org/diseases-conditions/urinary-tract-infection/symptoms-causes/syc-20353447>
- Mayo Foundation for Medical Education and Research. (2023, April 22). Period irregularities to get checked out. Mayo Clinic. Retrieved April 24, 2023, from <https://www.mayoclinic.org/healthy-lifestyle/womens-health/in-depth/menstrual-cycle/art-20047186>
- Menstrual Hygiene Products Exempted from GST. (2018, July 2021). The Hindu. Retrieved from <https://www.thehindu.com/news/national/menstrual-hygiene-products-exempted-from-gst/article24659043.ece>
- Nitnaware, H. (2022, October 17). India has pushed back poverty, still home to the most poor people in the world: UNDPIndex.
<https://Www.Downtoearth.Org.in/News/Governance/India-Has-Pushed-Back-Poverty-Still-Home-to-Most-Poor-People-in-World-Undp-Index-85502#:~:Text=The%202019%2F2021%20data%20observes,More%20than%2050%20per%20cent.> Retrieved February 28, 2023, from <https://www.downtoearth.org.in/news/governance/india-has-pushed-back-poverty-still-home-to-most-poor-people-in-world-undp-index-85502>
- Planned Parenthood. (2021). Tampons, Pads, and Menstrual cups.
<https://www.plannedparenthood.org/learn/teens/ask-experts/tampons-pads-menstrual-cups-which-best-me>

- Rodriguez, L. (2022). Period Poverty: Everything You Need to Know. Global Citizen. September 12, 2022. <https://www.globalcitizen.org/en/content/period-poverty-everything-you-need-to-know/>
- Roy, A., & Tandon, R. (2018). Barefoot College: A story of grassroots innovation. *Journal of Innovation and Entrepreneurship*, 7(1), 1-9.
- Sahoo, K. C., Hulland, K. R., Caruso, B. A., Swain, R., Freeman, M. C., Panigrahi, P., & Dreibelbis, R. (2014). Sanitation-related psychosocial stress: A grounded theory study of women across the life-course in Odisha, India. *Social Science & Medicine*, 120, 215-224.
- Sengers, F., & Wieczorek, A. J. (2019). Grassroots innovation: the inspiring challenge of bottom-up initiatives. *Journal of Cleaner Production*, 197, 1718-1727.
- Sharma, G. and Kumar, H. (2019). Commercialising innovations from the informal economy: The grassroots innovation ecosystem in India. *South Asian Journal of Business Studies*, 8(1), 40-61. <https://doi.org/10.1108/SAJBS-12-2017-0142>.
- Sommer, M., Caruso, B. A., Sahin, M., Calderon, T., Cavill, S., & Mahon, T. (2015). A time for global action: Addressing girls' menstrual hygiene management needs in schools. *PLoS Medicine*, 12(4), e1001803. <https://doi.org/10.1371/journal.pmed.1001803>
- Sumpeter, C., & Torondel, B. (2013). A systematic review of the Health and Social Effects of Menstrual Hygiene Management . *Plos one*, 8(4), Retrieved February 27, 2023, from <https://doi.org/10.1371/journal.phone.0062004>
- TEDx Talks. (2013, February 12). The sanitary pad revolution | Muruganandam Arunachalam | TEDxGateway [Video]. YouTube. https://www.youtube.com/watch?v=oQI0TngMm_0
- UNESCO. (2020). Global Action Programme on Education for Sustainable Development: Menstrual health and hygiene. Retrieved from <https://en.unesco.org/themes/education-sustainable-development/menstrual-health-and-hygiene>.
- van Lunenburg M, Geuijen K, and Meijer A. (2020). How and why do social and sustainable initiatives scale? A systematic review of the literature on social entrepreneurship and grassroots innovation. *VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations*. 31(5):1013-24.
- Venugopal, V and Abhi, S. (2013). A New White Revolution: Case Study of a Social Entrepreneur. *South Asian Journal of Management*. 20(4). 144-152.
- Yadav, J. (2021). Self-Help Groups and Women Entrepreneurship in India : Opportunities and Challenges. *AMC Indian Journal of Entrepreneurship*. 4(1). DOI: 10.17010/amcije/2021/v4i1/159225
- Yahoo! (n.d.). Inflation adds cost to menstrual products on top of the 'Pink Tax' and pandemic. Yahoo! Finance. Retrieved April 24, 2023, from <https://finance.yahoo.com/news/inflation-menstrual-products-more-expensive-182737880.html#:~:text=The%20average%20list%20of%20menstrual,the%20course%20of%20a%20lifetime>.
- Yin, R.K. (2017). Case Study Research and Applications: Design and Methods (Sixth ed.). Thousand Oaks: Sage Publications.

Econometrics of Social Interactions: A Way to Study the Social and Solidarity Economies?

Maheen Kannu M, Christabell P J

University of Kerala, India

Abstract

Human beings are social animals. The behaviour of one person can certainly be influenced by others in the society. The social interactions take place. Durlauf, S. N., and Ioannides, Y. M. (2010) refer the social interactions to “interdependence among individuals in which the preferences, beliefs and constraints faced by one person are directly influenced by the characteristics and choices of others”. It may seem like a pure sociological concept, but as we know it is the core of economics as well. There are some econometric models that have been used in the study of Social Interactions. The present paper focuses on the econometric models that have been used in the study of social interactions, the variables contained in the models and their relevance being included in the models. The purpose of the study is to critically look into some econometric models of social interactions from selected literature. To fulfil the objective of the study, secondary data such as articles are used.

Keywords: Social Interactions, Econometrics, Choices, Sociological, Influence, Utility, etc.

Key Words: Social Interactions, Econometrics, Choices, Sociological, Influence, Utility, etc.

1. Introduction

Interactions between the species is one of the most inevitable things in the world. They interact each other to make their lives possible. In their life each and every sort of interaction plays a crucial role. They interact to collect their livelihood, to cope with environmental disasters and other kinds of distortions, to sustain the food chain, to reproduce etc. Only with these interactions, the eco system can work well. Only if the eco system works well, the earth can move on for years without much difficulties.

Human beings, the most intelligent species in the world, make constant interactions to make their social life possible. They also interact to satisfy their own individual needs as well as social needs. When humans make interactions with other members in the society, the social interactions take place. The purpose of interactions of human beings may differ in matters (than that of other species), but same in substance; for their well-being.

The well-being of humans has been a spicy discussion of economists for many years. There have been discussions on how people make their choices to get maximum utility, how a society make efficient allocation of limited resources, how the behaviour of one person affect others' choices, etc. In orthodox economics, we often talk about the rational consumer whose behaviour is independent of others. But now, the way we look at the things has changed. We started looking at the behaviour of individuals, the choices they make, as an individual and as a social animal. Most of the times, the orthodox economics make unreal assumptions to get an appropriate result. It argued for less real facts with unreal assumptions. These unreal assumptions make more externalities to a model.

However, we started internalising the externalities, making more realistic models. Which means we take in to account the choices of others in someone's decision making model. In fact, when determining the decision of one individual, it is necessary to include all other social factors which can influence one's decision.

Statement of the Problem

Social interactions play a vital role in the working of an economy, particularly the Social and Solidarity Economy. As it is mentioned earlier, social interactions take place when others' choices intrude into or pulled (by the person her/himself) into a persons' choice. In Social and Solidarity Economy, it happens between marginalised, suppressed and isolated groups of people, even helping the larger economy to develop. It stands out as a social pillar for the neglected and stays stronger in the third sector. According to Caroline Woolard (2021), "all around the world the people who have been most harmed by our

current systems are practicing self-determination and community wealth. Mutual aid network, worker cooperatives, community land trusts, participatory budgeting and time banks have certain things in common, they are community ownership and democratic governance that builds political, cultural and economic power. When these hyper-local initiatives get together, they have enormous power. This emerging movement goes by many names but internationally, it is known as the Social and Solidarity Economy”.

The econometric models explain various social interactions, but hardly explain social interactions for the situations involving economic decision making. Even further, it could not explain the situations where social and solidarity economy has a crucial role to play.

Objective

The primary objective of this paper is to make a critique on the concept Econometrics of Social Interactions through the lens of SSE.

Methodology

Social interactions models have widely been applied in many situations. A considerable number of literatures are there in the field of social interactions. The models thereby used were varying according to different situations. To fulfill the study objective, secondary data such as articles are used.

Theoretical Framework

The study views the social economy through the lens of Neoclassical theory of economics. Neoclassical theory is unique in that it holds that economic outcomes are determined by inborn human nature. This idea holds that humans have the innate capacity for rationality and productivity needed to provide the greatest amount of wealth for a society. A specific set of social structures is what they require and have historically sought after in order to liberate and empower this inner human essence to realise its potential, which is the greatest possible well- being for the greatest number of people (Wolff, R. D., & Resnick, S. A. 2012).

According to neoclassical economic theory, each person's welfare is determined by the amount of commodities and services they consume: Maximise your consumption for optimum happiness. Of course, there is ongoing discussion regarding the scope of neoclassical theory, but most people would concur that this theory bases its fundamental behavioural assumptions on the maximisation of profit and utility by rational agents, the Pareto criterion serves as its guiding normative principle, and the general equilibrium of competitive markets serves as the model example of a well-functioning economy (Murrell, P. 1991). A well-known rationality assumption in neoclassical economics holds that given two

options, a decision-maker would select the one they believe to be the best (Lin, J. Y. 2005).

Conceptualisation Framework

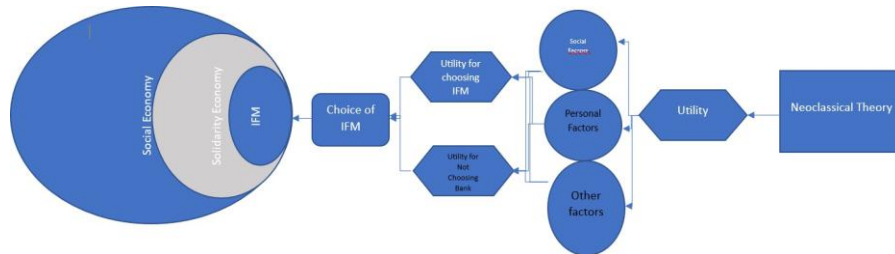


Figure:1 Conceptual Framework

A person's choice of an indigenous financial mechanism over other financial mechanisms, especially the formal ones, and participation can be studied through certain utility aspects: by considering him as an economic agent his prime goal is to maximise his utility. In this respect, as shown in the figure 1, the concept of utility can be used to measure how people make choices between any indigenous financial mechanisms and the formal financial systems. The utility of choosing or not choosing a financial mechanism depends on social, personal and other factors and based on the utility level which either of the financial mechanisms provide, the choice is made. The choice of a person can be measured through various tools. The various econometric models of Social Interactions become crucial here. The one best example is discrete choice models. The econometrics of social interactions are helpful, especially in the studies of social economy, because a person's choice might be influenced by other persons in the society as well. Many studies like that of Klonner, S. (2000), assumes the absence of other financial institutions to save or to get credit. But in reality, it may not be the case. What if other mechanisms are also available? The problem of choice arises as there is social interaction. An evaluation of the choice using an appropriate econometric model of social interactions would be helpful.

The following section details some interesting econometric models of social interactions. We cannot see much studies that use these models in the studies related to the social economy. But the application of these models would make a study of social economy more interesting.

Social Interactions

We can find the concept of social interactions everywhere and is very common within households, schools, workplaces and communities (Manski, C. F., 2013).

In the words of Durlauf, S. N., & Ioannides, Y. M. (2010), “by social interactions, we refer to interdependences among individuals in which the preferences, beliefs, and constraints faced by one person are directly influenced by the characteristics and choices of others. We emphasize the word directly as these interactions do not occur because of interdependences due to prices, as occurs in an Arrow-Debreu world. In fact, social interactions often represent externalities”. Bramoullé, Y., & Fortin, B. (2009) find social interactions in social networks. Social Interactions can be seen everywhere in the society. To study the results of various social interactions, the econometric models of social interactions have used. They are discussed in the following section.

preferences, beliefs, and constraints faced by one person are directly influenced by the characteristics and choices of others. We emphasize the word directly as these interactions do not occur because of interdependences due to prices, as occurs in an Arrow-Debreu world. In fact, social interactions often represent externalities”. Bramoullé, Y., & Fortin, B. (2009) find social interactions in social networks. Social Interactions can be seen everywhere in the society. To study the results of various social interactions, the econometric models of social interactions have used. They are discussed in the following section.

Econometrics of Social Interactions

Econometrics of social interactions applies the econometric models to study the social interactions in various situations. These models came through classical analysis of linear simultaneous equations (Manski, 2013). Mainly, two types of models are predominant in the studies related to social interactions. They are:

1. Linear-in-means Models (Manski, 1993) and
2. Discrete Choice Models (Tamer, 2003 and Brock and Durlauf, 2007)

1. Linear-in-Means Model

These are standard regression models of the type:

$$y_i = \beta_0 + \beta_1 X_i + \beta_2 \bar{y}_{g(i)} + \beta_3 m_{g(i)} + u_i \quad (1)$$

Here, the identification of social interaction is represented by the outcome of this model (y_i), $\bar{y}_{g(i)}$ is the expected average value of choice in the group $g(i)$, X_i represents the vector of the individual effects, $m_{g(i)}$ represents the vector constituting the contextual effects and u_i is the random error term representing the unobserved individual heterogeneity. To make $\bar{y}_{g(i)}$ in an observable form, an expectation operator can be applied to both sides of the equation. It will give the following expression

$$y_i = \frac{\beta_0}{1-\beta_2} + \beta_1 X_i + \frac{\beta_3}{1-\beta_2} m_{g(i)} + \frac{\beta_2}{1-\beta_2} \bar{y}_{g(i)} + u_i \quad (2)$$

These two equations have been used to study many social contexts. One significant study has been made by Lavy et al. (2008). They have studied the effect of low achievers among the peers. They found that low achieving students have a negative effect on the achievement of their peers.

➤ The Reflection Problem

Ultimately the reflection problem arises when there is linear dependence among the regressors. Multicollinearity can still be a problem in models even if linear dependence holds, so that the parameters are highly imprecise (Durlauf and Ionnides, 2010).

Manski (1993) explains various ways through which we can find that one person reflects the average behaviour of the group in which he/she belongs to; linear, non-linear, dynamic and demand analysis. There arises the failure of identification; nothing seems what it actually is. He explained the linear model in relation with three hypotheses:

- a) Endogenous effects,
- b) Exogenous (contextual) effects and
- c) Correlated effects.

Using the three hypotheses, one can identify whether the selected person reflects the characteristics of the group in which he/she belongs to. He specified the linear model as follows for an example of high school achievement of a teenage youth

$$y = \alpha + (y | x) + (z | x)' \gamma + z' \eta + u \quad (3)$$

Where, y = the achievement of youth in high school

x = the attributes of the reference group in which the person belongs to (school or ethnicity)

z, u = the attributes which affects y directly (such as socio-economic condition and ability)

The expected value of the random variable is

$$(u | x, z) = x' \delta \quad (4)$$

Now, $\alpha, \beta, \gamma, \delta$ and η constitutes the parameter vector. Now the linear regression has the following form

$$(y | x, z) = \alpha + (y | x) + (z | x)' \gamma + x' \delta + z' \eta \quad (5)$$

Now, the non-zero values of the parameters show the effect of independent variable on the dependent variable (y).

➤ Variance Based Approaches

Let us assume the following situation. Consider there are two persons A and B belonging to the group XA and XB respectively. The attributes of XA is different from that of XB . It means that the group-wise attributes affecting A and B are different from each other. These changes make the differences in average group behaviour. The effect may be due to the Social Multiplier Effect (Glaeser et al., 2003).

Glaeser et al. (1996) studied the social interactions in the case of crime numbers. As we all know, a person who have good social bonding may tend to attempt a few crimes only, with some exceptions like psychopaths. But the case is different for isolated or lonely people or for those who have less social bonding. There may be exception for loneliness, there are people who enjoy loneliness. But as we said earlier, nothing seems what it actually is. Glaeser et al. (1996) were concerned to study the incidence of crime for the US metropolitan areas. Their study led to some interesting conclusion that, the smaller the group interactions, the greater the tendency for more serious crimes to take place.

Glaeser et al. (2003) used the idea of social multiplier, which is a tool for comparing group variances. They used within group regression model:

for individuals $y_{ig} = K + \pi X_i + \eta_{ig}$ (6) and

for group level averages $\bar{y} = K' + \pi' x_g + \bar{\eta}_g$ (7)

Here the coefficient π and its counterpart π' are used to find the ratio; the social multiplier.

2. Discrete Choice Models

Discrete choice models are the most commonly used models to study the social interactions than the linear-in-means models (Durlauf and Ionniaides, 2010). The method can be used when someone have a discrete set of choices. Durlauf and Ionniaides (2010) derives the discrete choice model to derive someone's decision when someone have a discrete set of choices as follows:

$$V_{i,l} = h_{i,l} + \sum_{s=1}^L \sum_{j \neq i} J_{i,j,l,s} P_{j,s|i}^s + \varepsilon_{i,l} \quad (8)$$

Here, suppose that the person i , from the population I , has a set of choices S [where $S = \{1, \dots, L\}$]. From the set S , he chooses l . Then his total utility function, will have three parts:

- i. Private Deterministic Utility
- ii. Social Deterministic Utility
- iii. Random Individual Utility

iv. Private Deterministic Utility

Each person has his/her likes and dislikes and it is of greater importance when he/she makes a choice. It evolves from his/her own thought process, which makes him/her unique from others. It is of private in nature and forms private deterministic utility part. In the equation 8, the private deterministic utility is represented by the term $hi,,$ i.e., the private utility i for the choice l . But a person's life cannot completely be private as far as he/she is a social animal and not a lone wolf. The society is crucial.

ii. Social Deterministic Utility

The person's choice of selecting l might have had some influences from the group (i) in which he/she belongs to. That is, the thought that how other people think about choosing l has an influence over the choice of i selecting l . It shows the dependency of the person i with other members in the group (i) and forms the social deterministic utility part of the model.

Given another person j from the population I and the person make the choice s from the set S , then the social utility of i can be expressed as $Ji,,,$. It is not based on the actual observation, but on the probability, that j will choose s , the person i chooses l . The probability can be expressed as $P_{j,s|i}$. Then the person assigns the probability for all the other members in the society. It makes the social utility additive, hence the term

$$\sum_{j \neq i}^I J_{i,j,l,s} P_{j,s|i}^e$$

The case is true for all other choices in the choice set S . Thus, the social deterministic utility term becomes

$$\sum_{s=1}^L \sum_{j \neq i}^I J_{i,j,l,s} P_{j,s|i}^e$$

Hence, the choices of all other members in the society enters the model.

iii. Random Utility Term

A model become econometric model when we allow the stochastic error term to enter the model, i.e., $\varepsilon i,$. It is assumed that the error term is independent across all the members in the population (is) and all the choices in the set (ls).

Due to these attractive characteristics of the discrete choice models, they have been used to study a distinct variety of situations, where the social interaction matters a lot. Durlauf and Ionnades (2010) comments that these models have been used to study many situations, still you can find conflicting results in the

literature. Does it question the reliability of the discrete choice models that have been developed this far?

Some Observations and Critique

- It is certain that the econometric modelling has been widely used to deal with social interactions. It makes the models, which have been used to study the society, more realistic. It does not apply unnecessary and unrealistic assumptions to the model.
- Although we have come through two important econometric models of social interactions, the discrete choice model has been the crucial one in the study of social interactions.
- We can see from the literature that, almost all the studies had been conducted in the sociological contexts. We can hardly find a study confined to pure economic context. Even further it is hard to find studies confined to social and solidarity economics.
- Moreover, the literature shows that the empirical evidences for social interactions is not decisive. It is also important to note here that the interactions, and its intensity, purpose, and consequences, within each group and among each group and across choices are different.

Conclusions

The paper now has come to the conclusion with some exciting insights on the econometrics of social interactions. No matter that the area is new, the number of literature available there in the field is considerable. As it is seen earlier, the econometric models, particularly the discrete choice models, stayed as a pillar to those who were the inquisitors of knowing how one makes choices given the choices of others in the society, especially when the social interaction is important to a greater or fuller extent. Still, they are sociological. The econometric models of social interactions scarcely deal with economic matters. Thus, the empirical studies conducted may seem purely sociological, and yet they are indecisive. The econometric models stay away from the main stream economic matters, when we take into account social interactions. As it is so, could it be used to explain the social interactions in situations where social and solidarity economics has a crucial role to play? May more sophisticated econometric models of social interactions be able to deal with the emerging field of economics, i.e., the Social and Solidarity Economics.

References

- Durlauf, S. N., & Ioannides, Y. M. (2010). Social interactions. *Annual Review of Economics*, 2(1), 451-478.
- Linares, N., & Wollard, C. (2021). Solidarity not charity: Arts & culture grantmaking in the solidarity economy.
- Manski, C. F. (2013). Identification of treatment response with social interactions. *The Econometrics Journal*, 16(1), S1-S23.
- Bramoullé, Y., & Fortin, B. (2009). The econometrics of social networks. *Cahier de recherche/Working Paper*, 9(13), 1351.
- Manski, C. F. (1993). Identification of endogenous social effects: The reflection problem. *The review of economic studies*, 60(3), 531-542.
- Tamer, E. (2003). Incomplete simultaneous discrete response model with multiple equilibria. *The Review of Economic Studies*, 70(1), 147-165.
- Brock, W. A., & Durlauf, S. N. (2007). Identification of binary choice models with social interactions. *Journal of Econometrics*, 140(1), 52-75.
- Lavy, V., Paserman, M. D., & Schlosser, A. (2012). Inside the black box of ability peer effects: Evidence from variation in the proportion of low achievers in the classroom. *The Economic Journal*, 122(559), 208-237.
- Glaeser, E. L., Sacerdote, B., & Scheinkman, J. A. (1996). Crime and social interactions. *The Quarterly journal of economics*, 111(2), 507-548.
- Glaeser, E. L., Sacerdote, B. I., & Scheinkman, J. A. (2003). The social multiplier. *Journal of the European Economic Association*, 1(2-3), 345-353.
- Murrell, P. (1991). Can neoclassical economics underpin the reform of centrally planned economies?. *Journal of economic Perspectives*, 5(4), 59-76.
- Lin, J. Y. (2005). Viability, economic transition and reflection on neoclassical economics. *Kyklos*, 58(2), 239-264.
- Wolff, R. D., & Resnick, S. A. (2012). *Contending economic theories: neoclassical, Keynesian, and Marxian*. MIT Press.
- Klonner, S. (2000). *Rotating Savings and Credit Associations as Insurance*. Sudasien Institut der University Heldeberg, Working paper.

Analysis of the Functional Dynamics of Innovation for Inclusive Development Systems: An Event History Analysis of the Nigerian Growth Enhancement Support Scheme

David Adeyeye

National Centre for Technology Management, Ile-Ife, Nigeria

Sara S. Grobbelaar

Stellenbosch University, South Africa

Abstract

Several studies have explored and examined the performance of technology innovation systems by assessing the functional dynamics. However, not much has been done in this regard in the context of innovation for inclusive development systems (I4IDS). This paper, therefore, aims to contribute to the conceptual and methodological basis of the I4IDS by assessing the performance of the Innovation system (IS) in a sector vital to the BoP market (agriculture) in Nigeria. This paper seeks to answer the following questions: How can the functions of innovation systems be used to analyse the dynamics of the I4IDS? What inducement and blocking mechanisms determine the evolution of the I4IDS? and Which motors of innovation can be identified within the domain of the I4IDS?

In other to achieve these, we developed an analytical framework for analysing the performance of I4IDS and apply the same to the GES Scheme in Nigeria's agricultural system. This was undertaken using the 'event history analysis' method and complemented with 53 key informants and in-depth interviews. These allow us to map the events, analyse the interactions between system functions, and build a narrative that examines over time the functional dynamics of the I4IDS. We then utilized Causal Loop Diagrams (CLDs) to explore and explain how different functions play a role in each of the GES phases. Through this, it becomes practicable to assess the interaction of system functions in a way that sets up a cumulative causation process toward a build-up or breakdown of the I4IDS, as well as identify the dominant forms of cumulative causation (motors) in each episode. In addition, the typology of motors of innovation

literature is expanded to cover two new motors relevant to the I4IDS context: demand-pull and interaction motors. It is the belief that the use of motors of innovation in the I4IDS context will contribute to the theoretical underpinnings of the emerging literature on the systemic evaluation of ISs.

Key Words: innovation for inclusive development, inclusive innovation systems, event history analysis, innovation system performance

1. Introduction

Innovation is recognized globally as a driver of economic growth. The capacity to create, imitate, use, and modify innovations is seen as central to the successful growth of firms and countries (Cassiolato et al., 2013). This implies that firms have to continuously create a system of learning new knowledge and utilizing these in their production processes. The process of competence and capability building is dependent on the resources available to firms, their networks, absorptive capacity, and the institutional frameworks guiding their activities. These factors cumulatively influence the development of innovation systems and explain the differences between innovation systems in developing countries from developed countries. For instance, studies have confirmed investments in R&D capability and S&T infrastructure as important capabilities used by firms in developed economies for innovation while in developing countries, firms rely on the acquisition of new machinery and imitation of the products and processes developed in advanced countries (Egbetokun et al., 2017). They, therefore, rely on market sources to mask their weak interaction with knowledge institutions resulting in the implementation of incremental innovation, mostly at the firm level.

Questions have been asked on the relevance and appropriateness of the innovation system (IS) framework to inclusive development. Does it need to be modified? And, if so, how? (Cozzens & Sutz, 2012; Mackintosh et al., 2007). In refining the IS framework, many scholars have developed new concepts to tackle the perennial developmental challenges of inequality, poverty and unemployment in developing countries. These include user, social, open, frugal, inclusive innovation and I4ID (Gault, 2010; Kraemer-Mbula & Watu, 2010; Lizuka, 2013; OECD, 2015). There is a rising interest in the concept of the I4IDS due to the need to expand the conventional IS framework to accommodate the development peculiarities of the marginalised (Heeks et al., 2013). This is because ISs in the context of development focus not only on economic growth but on how to cater for lower income groups, the poorer segment of society, as well as the marginalised by innovating in such a way that their welfare is enhanced (Cozzens & Sutz, 2012; Paunov, 2013).

It is essential to note that in literature, most authors use the terms I4IDS and inclusive innovation system (IIS) interchangeably. However, Chaminade, Lundvall and Haneef (2018) attempt to differentiate between the two. They argue that IIS literature focusses on implementing innovations by adapting the structures and functions to the peculiarities of developing countries while I4IDS literature tries to reorientate the IS framework to tackle perennial challenges associated with developing countries. We argue that the use of the two terms interchangeably may be justified because the adaptation of the structural elements- actors, interactions and institutions - and the activities that make up an IS is usually an important step in re-orientating the IS framework for inclusive development. Although the term I4IDS is used in this paper, the framework captures the essentials of both the IIS and I4IDS.

In this paper, we evaluate a government intervention programme in Nigeria's agricultural system aimed at delivering subsidized inputs to smallholder farmers enabled by ICTs – the Growth Enhancement Support (GES) Scheme. The aim is to examine how the dynamics in an IS contribute to inducing or blocking the successful evolution of the GES. This is done by adapting a qualitative and empirical method, namely the event history analysis (EHA), to the I4IDS. While the EHA has been established as a method for exploring the TIS's functional dynamics and performance (De Oliveira & Negro, 2019; Hermans et al., 2019; Negro et al., 2007; Suurs, 2009; Suurs et al., 2010; Vroon et al., 2022), its use in the I4IDS is limited. The only study found in the literature examined the case of ICT for a development project for elderly rural women in Mafarafara in Limpopo, South Africa (Maarsingh, 2022). In this study, the EHA is used to explore the performance of an I4IDS by constructing a historical narrative of its evolution through the events that map the activities of the GES scheme. Events constitute the primary analytical unit. These can be interpreted in two ways: concrete facts, capturing what is happening within the level of structural factors, and concepts explaining the performance of a system as a whole (Suurs, 2009). Tracking events and constructing a narrative around the evolution of events in an IS enable a researcher to determine the system's dynamics.

This study, therefore, seeks to contribute to the emerging literature on I4IDS by assessing the performance of the IS in another sector vital to the BoP market (agriculture) in another developing country (Nigeria). This paper seeks to answer the following questions:

- Can the system functions be used to describe and analyse the dynamics of the I4IDS?
- What inducement and blocking mechanisms determine the evolution of the I4IDS?
- Which motors of innovation can be identified within the domain of the I4IDS?

1.2 Literature Review: Functional Dynamics and Innovation Systems' Performance

The performance of ISs can be better understood by investigating the system dynamics rather than only considering the actors in the system, which indicates the system's structure (Suurs & Hekkert, 2009). Here, understanding system dynamics from the perspective of processes or activities provides a better understanding of IS performance. These processes or activities are referred to as system functions. Hence, functions are all the activities within an IS that contribute to the development and diffusion of innovations (Jacobsson & Bergek, 2006a). The development of an IS is influenced by the contribution of the different structural elements, that is, actors, institutions, interaction, and infrastructure, to the activities that make up the system. Therefore, system functions make suitable intermediate performance criteria. While there is no consensus on the list of the functions, several authors have coalesced around seven: Entrepreneurial activities; Knowledge development; Knowledge diffusion; Guidance of search; Resource mobilisation; Market formation; and Creation of legitimacy (Bergek, Jacobsson, Carlsson, et al., 2008; Hacking et al., 2019; Jacobsson & Bergek, 2006b; Reichardt et al., 2016; Wieczorek & Hekkert, 2012). In this study, the list is expanded to include an additional function – the development of positive externalities. This is usually not used by many authors undertaking functional evaluation of ISs. However, we found it important because the adoption and diffusion of innovations within I4IDS have the potential for positive externalities and spillover effects to other actors in the system (Bergek, Jacobsson, & Sandén, 2008; Lizuka & Gebreyesus, 2017). According to Bergek, Jacobsson and Sandén (2008), positive externalities are a measure of the power of the collective dimension of the innovation and diffusion processes and is an indicator of the overall performance of an IS since externalities magnify the strength of the other functions. The functions used in this study and the relevance to I4IDS context are described in Table 1.

An important finding in studying functional dynamics is that functions interact with one another in a cyclic way leading to the build-up or breakdown of the system. It is this process over time that is referred to as cumulative causation. The theory of cumulative causation was credited to Gunnar Myrdal, a Swedish economist. The theory views the process of economic change as endogenous and driven by circular and cumulative effects in the economic process (Fujita, 2007). Analysis of the feedback loops of functional interaction provides insight into the dynamics of the IS (Bergek, Jacobsson, Carlsson, et al., 2008).

One method used in analysing the functional interaction, system dynamics and performance is the EHA. The EHA adopts a process methodology to analyse research questions on how change unfolds in organisational entities (van de Ven & Poole, 1995). Change in this context is seen as a succession of events, stages, cycles, or states in the development or growth of an organisation, programme or project. That is why the EHA is referred to as a process

approach, a method used to map the critical activities in a social system and their interactions with the system's growth. The main objective usually is to undertake a real-time collection of events of a social system as they unfold to understand the factors driving the system. van de Ven (1992) argues that to reduce the likelihood of bias, it is better to undertake a historical study before the outcomes of a strategic change process are known or launch a real-time study of the process as change occurs. However, Suurs (2009) makes a case for the EHA to be used as an ex-post method when assessing the change process in a TIS. This is because of the size and heterogeneity of activities in a TIS and the fact that change processes in a TIS typically take time.

Several studies have been conducted to assess the functional dynamics of TIS using the EHA. Examples include biomass digestion in the Netherlands (Negro et al., 2007); biomass digestion in Germany and biomass digestion in the Netherlands (M. P. Hekkert & Negro, 2009), as well as five cases of alternative energy development in Netherlands and Sweden (Suurs, 2009). The studies confirmed the validity of the use of IS functions in explaining the technological change process. Suurs (2009) refers to the cyclic relationship if particular system functions reoccur in an ordered sequence manner. The complementarity could be positive or negative. When positive, the event sequence forms a repetitive loop of system functions reinforcing each other towards the build-up of the I4IDS. This is usually referred to as a virtuous cycle. However, when the event sequence results in conflict, complete standstill or breakdown of the I4IDS, a vicious cycle is said to have occurred (Suurs, 2009). These reinforcements of interaction among functions are referred to as cumulative causation, and the dominant form of interaction is called the motors of innovation. Five motors were identified: entrepreneurial, market, science and technology push, system-building, and motor of decline (Suurs, 2009). In principle, multiple forms of cumulative causation may exist at different episodes of an IS depending on the nature of interactions between the functions and the final outcome. Identifying the various forms of cumulative causation, or motors forms the core of our analysis. In addition, the typology of motors of sustainable innovation is expanded to a new motor relevant in the I4IDS context: the demand-pull motor. In demand-pull, investments in new markets are determined by opportunities created by changes in market conditions (Nemet, 2009). Regulatory demand-pull policies have become an effective catalyst in the formation and growth of new markets (Hannon et al., 2015). These become more important in the context of I4IDS, where regulatory policies are needed to stimulate private-sector participation in BoP markets which are usually considered unprofitable (Prahalad & Hammond, 2002).

Table 1: Functions of innovation systems and their application in the I4IDS context

Functions of IS	Issues about the I4IDS
	These form the core of innovation activities. Entrepreneurs take innovation to the market. In I4IDS, the by unconventional actors, usually small enterprises and smallholders. Entrepreneurs are out of necessity rather than out of opportunity.
Entrepreneurial activities	
Knowledge development	This is driven by the process of learning. The kind, breadth or diversity of knowledge a firm is exposed to will determine the likelihood of success of its innovation efforts. In I4IDS context, knowledge development is driven by non-R&D modes, the DUI mode facilitates learning. Market-pull strategies take the requirements of the marginalised into account.
Knowledge diffusion	Diffusion of knowledge within an IS occurs through interaction among various actors occurring in networks. Within the I4IDS, diffusion is based on strong, informal social ties and networks. Informal intermediaries play an essential role in diffusion.
Guidance of search	This refers to the activities within the IS that can positively affect the visibility and clarity of specific wants among technology users (M. Hekkert et al., 2007). It helps to set priorities and direct investments towards achieving the goals of the IS. Within I4ID context, government is at the heart of designing policies and setting targets and promises; experience from previous programmes influences trust. There is the need for clear plans, structured targets, incentives, and governmental policies toward inclusive development.
Resource mobilisation	Resources are important factors in developing and introducing new technologies. These include financial and physical resources(van der Merwe, 2017). There is the need for alignment ofresources to the needs of the I4IDS. This includes incentives for successful scaling programmes or innovations to encourage local entrepreneurs to participate actively
Market formation	The market formation process is important for a new or transforming technology in ISs. Market formation is often characterised by an immature market, unarticulated demand by potential customers, and uncertainties in many dimensions (Bergek et al., 2008).

	Since most firms operating in the BoP markets are small and resource constrained, there is the need to introduce fiscal and monetary instruments to aid the diffusion of technologies within I4IDS
Creation of legitimacy	Legitimacy concerns the social acceptance of new technologies and compliance with relevant institutions (Bergek <i>et al.</i> , 2008). This is important to generate demand and mobilise the needed resources to drive innovation. It is essential to form legitimacy around a market and, more importantly, around the BoP markets
Positive externalities	Positive externalities are referred to as beneficial spillover to a third party or parties because of the implementation of an innovation. Spillover effects help to enhance the sustainability and legitimacy of I4IDS programmes

1.3 Methodology

1.3.1. Data

To generate insights into the performance of the I4ID system, the study was conducted to develop an analytical framework for expanding the IS framework to inclusive development. In order to demonstrate the utility of the framework in an inclusive development context, it was applied to the GES case to generate insights into the functional dynamics and performance of an IS. Data was sourced through key informants and in-depth interviews (KIIs and IDIs) conducted with key actors in the agricultural system that participated in the GES scheme. IDIs were conducted with smallholder farmers, managers or owners of agro-dealers, and input suppliers. The number of actors interviewed depended on theoretical saturation – where the conduct of new interviews was contingent on new knowledge from additional respondents (Mack *et al.*, 2005). KIIs were conducted with policymakers at the State and Federal Ministries of Agriculture and Rural Development, the Technology Developer, Supply Chain Managers, intermediary associations (e.g. industry and farmers' associations), and financial institutions, who were selected purposively. As gatekeepers of knowledge, they provided in-depth information about their business operations and other variables of interest to the study. In total, 53 interviews were undertaken for the actors in the GES Scheme. The framework development process followed a modified and adapted systemic policy approach developed by Wieczorek and Hekkert (2012). The approach provided a holistic framework for developing insights into the functional dynamics and performance of ISs by integrating four different evaluation approaches – component, functions of the innovation system, systemic problem, and systemic instrument frameworks.

The 6-stage adapted process consists of the following: defining the system boundaries, mapping the structural elements; performing component-function analysis; identifying systemic problems; identifying systemic instrument goals, and designing systemic instruments to achieve the goals. Similarly, the framework application process is undertaken through three main methods: the EHA, primary data collection, and consultation of experts.

In undertaking the functional analysis of the GES scheme, the EHA follows the following process: literature search and data collation; database construction; allocation of events to functions; construction of narrative; identification of trend and interaction patterns; and triangulation of results. The EHA is analysed along the different stages of the growth of the GES, called episodes. These are identified, the historical narrative described, and the trend and pattern analyses examined. These are summarized in Table 2 and described below

Table 2: Stages and tools of the EHA as used in this study

Stages of EHA	Steps and tools
Literature search and data collection	An online search on Google Scholar
Database construction	Identify events and arrange them chronologically. Events, ID, Year
Allocation of events to functions	Identify episodes; narrative Develop the narrative
Identification of patterns	
Trend pattern <i>(It derives trends from aggregated data over aperiod).</i>	Trend pattern Charts and graphs Give-receive-participate framework
Interaction pattern <i>(track causal chains of events based on the sequence in which they occur)</i>	Interaction pattern Causal Loop Diagrams Interaction pattern Causal Loop Diagrams
Triangulation of results	Qualitative data

1.3.2. The EHA Process

1.3.2.1. Literature search and data collation on GES Scheme

The first stage of the analysis involves searching online databases to retrieve a broad collection of documents and extract events about the GES scheme. The literature search was undertaken using the Google search engine (News). This includes newspapers, policy documents, journal articles, and technical reports. The selection was based on the criterion that the texts cover topics related to GES Scheme in Nigeria's agricultural system; hence, keywords such as "GES", "GESS", "Growth Enhancement Support", "Growth Enhancement Support Scheme", as well as "e-wallet" or "electronic wallet system" was used. In total, 168 events were retrieved. These form the basis of the analysis presented in this study.

1.3.2.2. Database construction

Every event related to the scheme was selected, stored and systematically allotted to specific system functions (Negro et al., 2007; Suurs, 2009). In this phase, the data collected is collated and sorted chronologically: event, reference, event description, and event category (Table 3). The 168 events were each assigned a unique identification number (ID). This is done by reading through the literature and identifying and collating events relevant to the functions. During the process, the conceptual framework of system functions was used as a heuristic (Suurs, 2009). This enables the researcher to link the events to each function and subsequently construct a timeline of the events of the GES as it evolves.

Table 3: Sample event classification used in the EHA

Event ID	Event year	Event
18	2012	Registration and enumeration of farmers at theward
26	2014	Selection and Registration of agro-dealers
138	2014	The NASC reported growth in Seed companiesfrom 11 in 2011 to 134 in 2014

1.3.2.3. Allocation of events to functions

After identifying and mapping events, the next step is allocating each event to specific functions. The process was guided by assessing whether each event leads to the fulfilment or otherwise of the particular activity. In cases where a single event contributes to more than one function, they were separated as

unique and allocated to different functions. Similarly, where several sources report similar events in the same period, the allocation to functions is reported once. Where events are repetitive activities across several years, they are only written in the first appearance and not allocated to any system function subsequently. During the process, three kinds of relationships are established. At the commencement of the process, all events were assigned the value zero. This changes to +1 whenever the event has a positive effect on the function, adding 1 to the total value of the function. On the other hand, the value -1 is assigned to the event whenever there is a negative influence, leading to a deduction of a value of 1 from the total value of the function (See the GES sample event database in Table 4). At the end of the allocation, the total value for each function is aggregated and used to plot the graphical illustration depicted by the trend pattern.

Table 4: Sample allocation scheme of events to function for the GES classification

ID	Year	Event	Occurrence	Recognisable activity	Applied function	Status	Episode	Value of functions		Total Values of functions	
								F1	... F8	F1	... F8
18	2012	Registration and enumeration of farmers	Single	Mapping of the marginalised groups within business models	F1	+ve	Pilot	1	0	1	0
26	2014	Selection and Registration of agro-dealers	Single	Entry of firms	F1	+ve	Scaling	1	0	2	0
138	2014	NASC reported growth in Seed companies from 11 in 2011 to 134 in 2014	Single	The emergence of new firms, actors or industries	F8	+ve	Scaling	0	1	2	1

1.3.2.4. Construction of narrative

The process of identification, categorisation, and construction of the event sequences, as well as describing the narrative, was done objectively as much as possible by the researcher using established procedures from similar studies on EHA (Maarsingh et al., 2021; Negro, 2007; Suurs, 2009). To minimise bias, experts subjected the process to constant review and the feedback was used to sometimes reallocate the events or reconstruct the narrative. The study utilises a naming system to identify each function: entrepreneurial activities (ENT); knowledge development (KDV); knowledge diffusion (KDF); guidance of search (GOS); market formation (MKT); resource mobilisation (RES); creation of legitimacy (LEG); and development of positive externalities (EXT).

The narrative provides a historical timeline of the changes in the dynamics of the functions. The outcome is a storyline of how the development of the I4IDS has changed over time and the role of the different functions in this evolution

(M. Hekkert et al., 2007). The historical timeline is constructed according to the episodes identified in the narrative. When combined with the trend and interaction patterns, the historical timeline provides a holistic view of the evolution of the trajectory of the growth of the I4IDS.

1.3.2.5. Identification of trend and interaction patterns

Trend patterns depict the fulfilment of the individual system functions and are used to identify significant developments of the functions in the narrative. During each phase, the events are used to provide further insights into how functions influence the development of each phase. These are illustrated using charts and graphs.

To ascertain the role of the actors in each event, a 3-category framework was developed: give- receive-participate. The actor initiating the event is classified as a 'giver' while the actor targeted by the giver as the direct recipient is classified as a 'receiver'. The third category (participate) refers to actors that are present in or facilitate the fulfilment of the event but are neither the initiator nor the direct beneficiary of the event. An example of an event is the redemption of inputs by farmers. While the government is the 'giver', the smallholder farmers are the 'receiver', and the agro-dealers and input suppliers are the 'participants' (Figure 1). The data analysis was undertaken using the database captured in the excel spreadsheet. For each event, the database captured the recognised activity, assigned functions, and actors' roles of the actors.

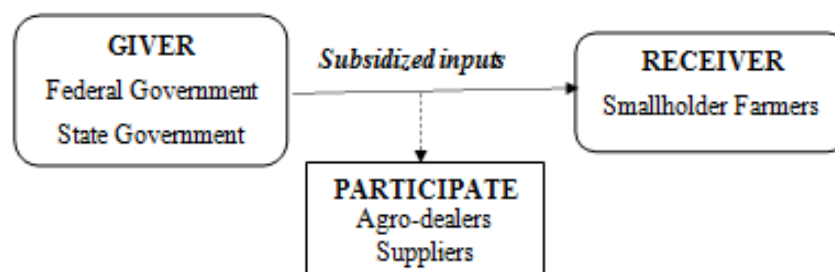


Figure 1: Schematic illustration of the give-receive-participate framework

The interaction patterns of the functions and the resulting cumulative causation or motor are identified and illustrated using the CLDs. These are part of various systems thinking tools that aim to understand systemic relationships over time (Maarsingh et al., 2021). CLDs summarise the cumulative causation in an episode of the I4IDS. They provide visual linkages and interactions between system functions, thereby identifying circular causation leading to positive or reinforcing mechanisms (Uriona & Grobbelaar, 2018).

1.3.2.6. Triangulation of results

In the process of analysing the EHA, triangulation serves two purposes. One is to develop a narrative that captures the reality of the events of the I4IDS from the perspective of the actors that participate in it and to create a normative stance towards this development (Suurs, 2009). To undertake this, interviews were conducted with the stakeholders in the GES Scheme. This enables the researcher to reconstruct, when necessary, the narrative with insights from the interviews.

1.4 Case Study : The Growth Enhancement Support (GES) Scheme

1.4.1 Introducing the GES Scheme

The Nigerian government introduced the GES Scheme in 2011 to enhance the efficiency of the procurement and distribution of agro-inputs among Nigerian farmers. The initiative is one of the pillars of the Agricultural Transformation Agenda (ATA) launched by the then Minister of Agriculture and Rural Development, Akinwumi Adesina, upon assuming office. Aside providing subsidised agricultural inputs efficiently, the scheme seeks to enhance agricultural productivity, farmer's income and food security (Onyekwena et al., 2018). To achieve these, the Scheme was segmented into the following components (GrowAfrica, 2016):

- Development of a competitive agro-dealer network;
- Stimulating the banking sector to finance the agro-dealer network;
- Uptake by farmers by creating a national farmers' database; and
- Delivery of the e-wallet through an IT platform

The GES Scheme functioned through an interconnection of different actors in the inputs supply system such as agro-dealers, input suppliers and extension agents to effectively deliver agriculture inputs such as fertilisers, seedlings, chemicals and others to farmers through an electronic voucher. Other prominent actors in the scheme are the helpline personnel, technology developer, finance institutions, State, and Federal Ministry of Agriculture officials. The voucher, referred to as an electronic wallet or simply an e-wallet, also serves as an avenue to educate, inform and communicate with farmers in rural areas across the country on the latest and best agricultural practices and the current prices of commodities in the market (Adebo, 2014).

Before the introduction of GES, government was the sole importer, producer, distributor, and regulator of the agricultural inputs system in Nigeria, the most important of which is fertiliser. As with most subsidy regimes, the sector was grossly underdeveloped and characterised by fraud and inefficiencies manifesting in late delivery and the diversion of fertiliser from intended

beneficiaries (Nagy & Edun, 2002). These include leakages of the product into the open market, distorting the market price and providing arbitrage opportunities and a lengthy and cumbersome bureaucratic tendering process (Minot & Benson, 2009). It was estimated that about 30% of farmers received subsidised inputs (GrowAfrica, 2016). Similarly, government's direct involvement in the procurement and distribution of fertilisers weakened the ability of private companies to participate in the sector and compete efficiently for market share.

With the commencement of the GES, the government withdrew from direct fertiliser purchase and distribution and introduced an alternative system of distribution built on the electronic voucher system. This led to improved efficiency in the procurement and distribution of agro-inputs. For instance, the programme was oversubscribed in the second year reaching about 14 million farmers, while fertiliser and seed companies recorded sales worth about \$100 million and \$10 million, respectively. In addition, banks lent \$20 million to agro-dealers with a zero percent default repayment (Adesina, 2015). Starting in 2014, the programme witnessed some challenges mainly from the inability of the economy to withstand the massive shock as a result of sharp decline in crude oil prices. Nigeria's economy was fatally hit because of its overreliance on crude oil for revenue and foreign exchange. Crude oil accounts for about 80% of government revenue and 95% of foreign exchange (Nwuke, 2021). This resulted in low government revenue and subsequent failure of the government to meet its subsidy obligations. These challenges finally resulted in the termination of the programme in 2018.

1.4.2 The Event History Analysis of the GES Scheme

The dynamic evolution of the GES is analysed in this section. The analysis reveals a detailed description of the development of system functions and the motors that occurred. The analysis is undertaken as a historical narrative of the evolution of the GES chronologically around the episodes (Figure 2).

The narrative section is followed by analyses of the trend and interaction patterns. In the development trajectory of the GES, the four episodes, description and the inducement or blocking factors are identified in Table 5. The episodes capture a specific trajectory of the events and the components that drive the activities from the formative, growth to the final stages of the GES.

Episode	GES Development	Inducing Mechanism	Blocking Mechanism
2011	Programme design and planning	High oil price, high food imports;market opportunities;new political leadership stakeholder commitments and buy-in	Weak or lack of institutions; lack of trust among actors; poor sensitization
2012	Emergence and experimentation	The utilization of the private sector in procurement and distribution of inputs; use of e-wallet technology for distribution of inputs	Scepticism; poor logistics
2013-2014	Scaling and acceleration	Increased trust among the marginalised smallholderfarmers; strong MEL; introduction of technological and non- technological innovations	Poor lending to small actors especially agro-dealers who are mostly SMEs; Logistics issues - a slow rollout of TAP technology used to overcome network issues in rural areas; Weak intellectual property rights laws on breeder seeds
2015-2018	Uncertainty, suspension,and final termination	Strong advocacyand lobbying by intermediaries	Economic recession, low government revenue from oil crash, change in government, lack of legal backing

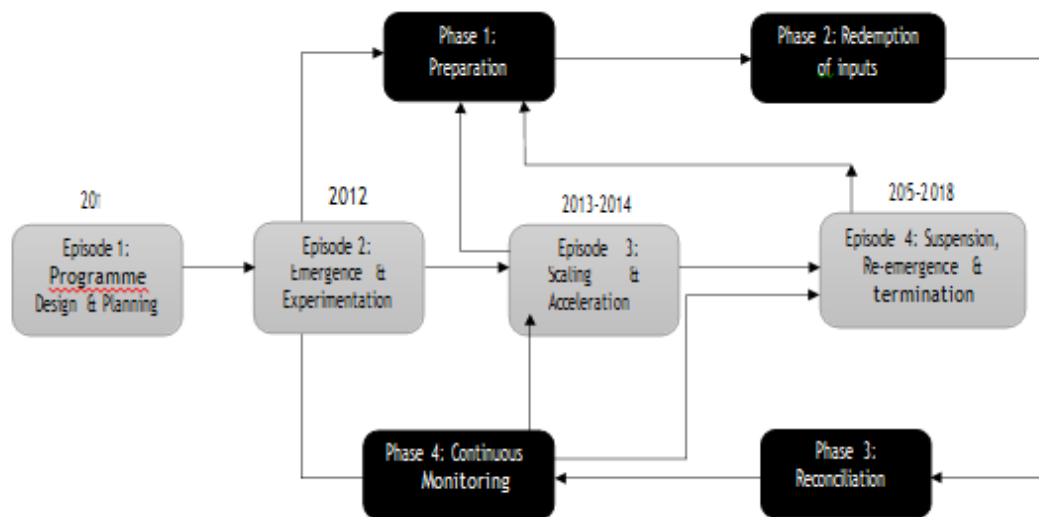


Figure 2 Schematic illustration of the iterative process of the episodes of the GES

1.4.2.1. *Episode 1: Programme Design and Planning (2011)*

This episode focuses on building a coalition of actors and forge consensus and buy-in on how to successfully implement the GES (F4/GOS) and incentivise the agro-input supply system to enhance market formation (F5/MKT). The activities included identification of stakeholders, their roles and responsibilities; stakeholders' engagement and articulation of vision and goals; targets' definition (F4/GOS); definition of operational framework; and creation of awareness and sensitisation (F3/KDF). The scheme aims to move smallholder farmers from subsistence farming to commercialised systems over a 4-10 year period to facilitate trade and competitiveness (Federal Ministry of Agriculture and Rural Development, 2011) (F4/GOS). To actualise this, the GES changed agricultural inputs procurement and supply from the public to the private sector. Subsequently, a meeting of the National Economic Council (NEC) was held on 10th November 2011, where the GES was endorsed as a new policy framework for providing access to agricultural inputs (F4/GOS). The NEC, headed by Nigeria's Vice President, has a membership of the 36 State Governors, the Central Bank Governor, and the Minister of Finance. The NEC further directed that the GES Scheme be implemented across all the States and the Federal Capital Territory (FCT) (F5/MKT). As part of the agreement, participating States committed not to undertake public sector procurement and distribution of farm inputs to ensure full market access for private sector participation and long-term sustainability (F5/MKT). The States and the FCT made a formal commitment through a written letter to partner with the Federal Government, contribute 25% to fertilizer subsidies (F6/RES), support the enumeration and development of farmers' database (GOS), and support the provision of warehouses for agro-dealers (F6/RES).

A study was commissioned to determine the baseline of the agro-input supply system (F2/KDV). To enhance the efficiency and effectiveness of the programme, Cellulant, an indigenous technology company, was engaged through a competitive process to develop and manage the GES database management system for three years (January 2012 - December 2014) (F6/RES). The contract sum was 1.3 billion Naira (F6/RES). The database management information system defines a set of standard operating procedures that monitors all transactions, provides checks and balances, and generates regular data for evaluating the performance of the GES on a day-to-day basis (F2/KDV). It also contains the names of all registered farmers, accredited suppliers, and agro-dealers. In addition, a National GES Working Group was constituted (F4/GOS) to oversee the subsidy programme implementation (F7/LEG) and recommend adjustments and corrections when needed (F3/KDF). At the State level, a similar working group was constituted (F4/GOS) and was chaired by the State Director of FMARD (F7/LEG). To ensure an effective day-to-day running of the Scheme, a national GES Coordinator was appointed (F6/RES). The government set a target of reaching 20 million farmers with subsidised inputs in 4 years, an average of 5 million farmers per year (F4/GOS). To provide access to funding for the actors who participated under the GES, the FMARD, the Federal Ministry of Finance, and the participating banks brokered an agreement (F5/MKT). High-interest rates were reduced through a back-end loan. Instead of collateral, the Federal Ministry of Finance provided a sovereign guarantee to cover 75% of a loan in the event of default (F5/MKT).

Episode 1: Analyses of the trend and interaction patterns

The analysis reveals the guidance of search (F4/GOS) as the prominent function (Figure 3). This involves activities introduced during the formative years of the project aimed toward target-setting, definition of roles, expectations, responsibilities etc. These served to enlist the buy-in of stakeholders critical to the programme's success. This was confirmed by the give-receive-participate framework which shows that functions (F4/GOS and F5/MKT) were the most 'given' function, while F4/GOS was the most 'received' by actors and most functions actors 'participate' in. Further analysis indicates that entrepreneurial activities (F1/ENT), knowledge diffusion (F3/KDF), and positive externalities (F8/EXT) were completely missing (Figure 4). The Federal Government's role as the enabler of the I4IDS at the design stage is also reflected. The Federal Government was the sole giver of direction (F4/GOS), providing resources (F6/RES) and enabling the coalition needed to kickstart the programme successfully (F7/LEG).

The analysis of the interaction patterns confirms the dominant function of the guidance of search (F4/GOS) led by the government (Figure 5 and Figure 6). This is expected because, in the I4IDS, private-sector participation is weak at inception because of the perceived unprofitable business model of the BoP

market. They only become strong with incentives facilitated by the government. In addition, other functions such as market formation, resource mobilisation, advocacy coalition, and knowledge diffusion were also prominent. Entrepreneurial activities, knowledge development and positive externalities are either weak or absent at this stage. Therefore, the prominence of guidance of search, especially by the government, leads to a conclusion that the cumulative causation is a demand-pull motor.

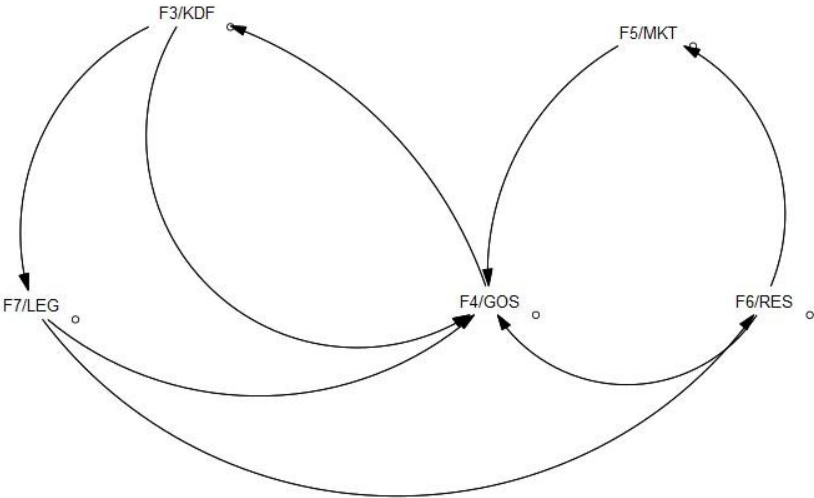
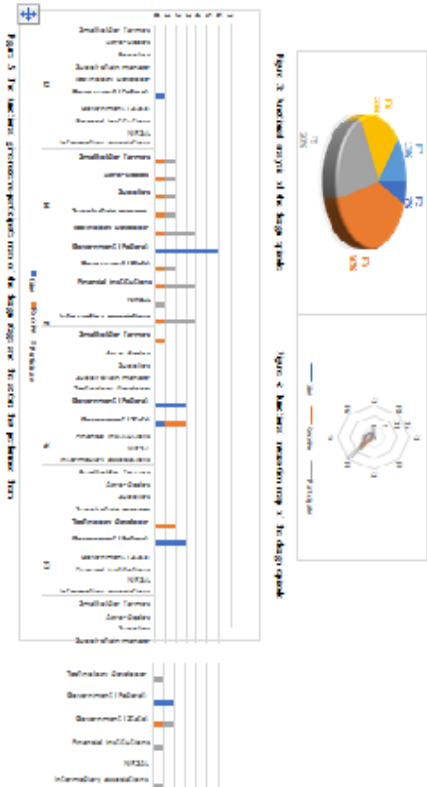


Figure 6: Functional dynamic of episode 1 – demand-pull motor

1.4.2.2. *Episode 2: Emergence and Experimentation (2012)*

The second episode marked the rollout of the programme on a national scale. The programme commenced with a national launch in Ede, Osun State, in July 2012. The Minister of Agriculture and Rural Development chaired the launch. The stage comprises sets of repetitive activities occurring annually until the end of the programme (Figure 2). Three repetitive phases, preparation, the redemption of inputs, and the payment of subsidies (Phases 1- 3), were executed each year as distinct activities. Another continuous activity, monitoring and evaluation, was implemented as a broad activity that permeates all three phases of Episode 2.

a. Phase 1: Preparation

The rollout of the Scheme commenced with a preparatory meeting (F3/KDF) initiated by the National Working Committee chaired by the Minister of Agriculture and Rural Development (F7/LEG). The meeting agreed on implementation modalities and an implementation timeline (F4/GOS). Key stakeholders such as farmers' unions, agro-dealers associations, suppliers, commercial banks, Central bank, Supply Chain Managers, the National Agricultural Seed Council and FMARD were represented at the meetings (F7/LEG). The structure was replicated at the 36 States and the Federal Capital Territory (K3/KDF), where the State Director of FMARD (F7/LEG) chaired the committee. To ensure the efficiency and integrity of the system, farmers were pre- registered using paper forms at the different wards across the country (F1/ENT). After completion of registration, their information was captured, analysed and developed into a database of smallholder farmers in Nigeria (F1/ENT), called the National Farmers Database (NFDB). Following a competitive bidding process, other participating actors, such as agro-dealers and input suppliers, were selected (F1/ENT). The agro-dealers were then mapped to redemption centres, which were expected to provide adequate inputs stocks in preparation for redemption (F1/ENT). Point of Sales devices and programmed tablets were deployed at each redemption centre to carry out the redemption process (F6/RES). As part of the preparation and due to poor ownership of phones among rural farmers, the FMARD planned a programme to facilitate the acquisition of phones where farmers were supposed to pay through the e-wallet at a subsidised rate (F2/KDV; F6/RES). However, the process was stopped due to a negative reaction from the public (-F6/RES) based on the misconception of corruption intent in the procurement process (-F7/LEG).

In addition, sensitisation and awareness were created in the mass media and other media platforms (F3/KDF). These include producing and airing documentaries of the GES programme on different media houses by the

FMARD, in collaboration with other stakeholders, such as the National Agricultural Extension and Research and Liaison Services (NAERLS) (F7/LEG).

b. Phase 2: Redemption of Inputs

After the preparation activities, government selected and announced the commencement of redemption (F4/GOS). The helpline officers were recruited, trained and deployed to the redemption centres by Cellulant in coordination with State ADPs (K3/KDF) officials, after which the redemption process began. The process usually takes 4 to 6 weeks (F1/ENT). Challenges with the redemption process included erratic or absence of telephone networks in many rural areas (- K6/RES). These led to the introduction of scratch cards (F6/RES); however, this proved insufficient to solve the challenges (-F1/ENT), resulting in long delays in the collection of inputs (-F1/ENT).

To make the GES inclusive of the various crop value chains and cover all the agricultural activities, the programme was divided into two: generic and special GES (F5/MKT). The generic GES provides registered smallholder farmers access to two bags of 50kg fertiliser and one of 12.5kg of the seed of rice or 10kg of the seed maize (F1/ENT). At the commencement of the national rollout in 2012, farmers were given seed/seedlings free while they were expected to pay 50% of the cost of fertiliser (F5/MKT). Each registered farmer is expected to have access to inputs under the generic GES (two fertilisers, seed (rice or maize)) in addition to the special value chain earlier captured during registration. In the first year, the Scheme was characterised with low patronage by farmers (-F1/ENT). Only 32% of the intended target, 1,608,148 farmers, was reached (-F4/GOS). This was attributed to low awareness (-F3/KDF), late rollout (-F1/ENT) and scepticism owing to negative experiences from previous governments' programmes (-F4/GOS). Despite these, a total of 26,325mt of certified seed of maize, rice, sorghum and cotton, amounting to about 6.13 billion Naira, were redeemed in 2012 (F1/ENT).

c. Phase 3: Reconciliation

To ensure efficient management of the Scheme, reconciliation was undertaken daily and at the end of the redemption season (F1/ENT). The outcome was uploaded into the GES database management system. A weekly report was submitted by Cellulant indicating sales made at specific centres and the amount of subsidy (F1/ENT). Before the final subsidy was paid, the figures were confirmed by representatives of key actors at the redemption centre, state, FMARD and Federal Ministry of Finance. The subsidy was then deducted from the State, and Federal Government accounts with the Central Bank of Nigeria (CBN) and paid directly to the input suppliers and agro- dealers (F5/MKT).

d. Phase 4: Continuous Monitoring

The implementation of the GES was characterised by continuous monitoring and evaluation, which permeates all the activities of the Scheme. As noted earlier, weekly reports were submitted by Cellulant to FMARD, which reflects performance indicators such as farmer participation, inputs redemption, and service delivery. The reports formed part of the inputs used by the GES Working Group during their weekly review meetings to evaluate programme progress, identify improvement areas, and implement them on behalf of FMARD (F1/ENT). At the State level, a monitoring team comprising officials of FMARD and the State Ministry of Agriculture was constituted (F4/GOS). The team conducted a physical inspection of the various redemption centres every week to monitor the implementation of the Scheme and resolve any challenges that may occur (F1/ENT). Banks also monitored the loans through an online portal to the database management system (F1/ENT). Based on the financing scheme by the FMARD and the Federal Ministry of Finance, some six banks loaned \$25 million in 2012, which was considerably lower than the target (F6/RES; -F4/GOS). To review the implementation of the rollout, the Fertiliser Suppliers Association of Nigeria (FEPSAN) undertook an independent study (F2/KDV) to assess success and constraints and make recommendations to improve the scheme in the coming cycles.

Episode 2: Analyses of the trend and interaction patterns

The most critical activity in this episode is the redemption of subsidised agro-inputs. This led to a rise in activities under the GES, making the entrepreneurial function (F1/ENT) the most prominent function in this episode (Figure 7). Prominent entrepreneurial activities included the entry of firms through the activities of the agro-dealers, suppliers, etc., monitoring and evaluation by government officials, registration of smallholder farmers and redemption of inputs by smallholder farmers. These stimulated the fulfilment of other functions such as resource mobilisation (F6/RES), creation of legitimacy (F7/LEG) and knowledge diffusion (F3/KDF).

The give-receive-participate framework shown in indicates the non-existence of the F2/KDV and F8/ENT (Figure 8) in this episode. The most given function is F1/ENT, while F1/ENT, F7/LEG, F6/RES and F4/GOS are the most received functions. In addition, F3/KDF was the function mostly participated by actors. The analysis reveals that the Federal Government continued to play a significant role in driving the activities of the emergence episode by performing the 'giving' role in F1/ENT, F3/KDF, F4/GOS, F5/MKT, F6/RES and F7/LEG (Figure 9). However, the episode witnessed the rise of other actors in the 'given' role, with Cellulant playing an essential role in F1/ENT and F6/RES, as well as agro-dealers and financial institutions in F1/ENT. Smallholder farmers and agro-dealers mostly performed the receiving role. Also, these same actors performed important receiving roles in the F6/RES function. Agro-dealers

received and deployed inputs and technologies to manage the operations at redemption centres, while smallholder farmers received SMS on the e-wallets on their mobile phones.

Overall, four functions drove the episode. These are entrepreneurial function (F1/ENT), creation of legitimacy (F7/LEG), resource mobilisation (F6/RES) and diffusion (F3/KDF) (figure 10). Because the GES at this episode is in an experimental mode, the government needed to build a coalition (F7/LEG), engage different stakeholders (F3/KDF) and mobilise financial, technological and human resources (F6/RES) to enhance the rapid diffusion of the Scheme. These went a long way to overcome the initial distrust of the Scheme among other stakeholders (F4/GOS), especially the private sector players, and facilitated their participation (F1/ENT). The experience of actors provided appropriate feedback (F2/KDV), which further enhanced the operational efficiency of the Scheme. Different functions were however dominant in the different phases: Phase 1, coalition formation (F7/LEG), sensitisation and preparation activities (F3/KDF); Phase 2, the redemption of inputs (F1/ENT; F6/RES); and Phase 3, reconciliation (F1/ENT). Phase 4, continuous monitoring (F1/ENT), meanwhile permeated all the three preceding phases. This episode can therefore be termed as entrepreneurial motor.



Figure 7: Fractional analysis of the emergence stage

Figure 8: Fractional interaction map of the emergence episode



Figure 9: The fractional agro-ecotone-participative map of the emergence stage and the actors that professed them

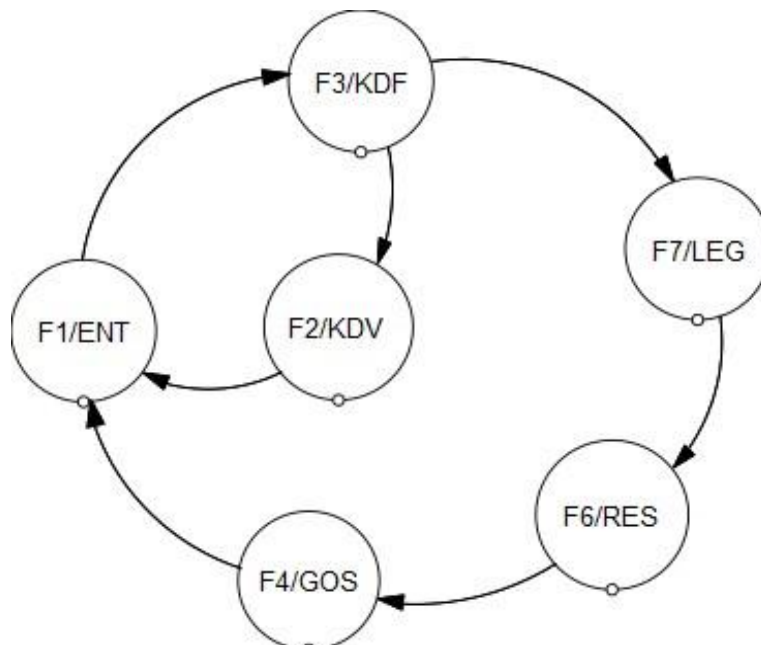


Figure 10: Functional dynamics of episode 2 – entrepreneurial motor

1.4.2.3. *Episode 3: Scaling and Acceleration (2013 – 2014)*

The year 2013 marked the second year of the rollout of inputs distribution under the GES and the third year of implementation of the Scheme. Central to the rollout in the second year was feedback from the continuous learning process from the activities in the previous year (F2/KDV). This led to modifications and continuous improvement in the three phases of the rollout stage (F1/ENT). The rollout started with the year's preparatory process; operational modalities and action plans were discussed and agreed (F3/KDF). Another key activity was the review of the NFDB (F1/ENT). This removed fake farmers and expanded the database to register new ones (F1/ENT). To avoid the need for manual input of high volumes of registration forms, the system was revised in 2013 (F2/KDV). Optical Mark Recognition (OMR) form was introduced (F6/RES) and used for registration (F1/ENT). Enumerators marked the information on a pre-printed sheet, which was later scanned and uploaded into the database. Farmers' information was captured if they visited the enumeration site in person. They were also provided with a tear-off slip as proof of registration. To reduce the challenges associated with poor telephone networks, an offline system with paper vouchers was adopted for redemption (F1/ENT; F2/KDV; F6/RES). The special GES was subsequently expanded to include new value chains (F1/ENT).

The increase in awareness about the programme (F3/KDF) and the acceptance among stakeholders (F4/GOS) led to high turnout of farmers in the second year of rollout (F1/ENT). At the end of 2013, 5,855,538 farmers at various redemption centres in 36 States and FCT redeemed a total of 63,629mt of rice, maize, sorghum, soybean, groundnut and cotton certified seeds valued at 14.6 billion Naira with government paying 26 billion Naira as subsidy to agro-dealers (F6/RES). A total of 45 seed companies also participated in the scheme (F1/ENT). To enhance the operational efficiency of the programme, due diligence and performance reviews of agro-dealers and input suppliers were undertaken at the commencement in 2013 (F2/KDV). The outcome led to the removal of non-performing agro-dealers and suppliers from the programme (F1/ENT) and were replaced with others on the waiting list. In addition, FMARD engaged three private sector players (IFDC, Jetlink Limited, and Ecalpemos Technologies Limited) as Supply Chain Managers (SCMs) (F6/RES).

Arising from feedback from actors on the funding performance (F2/KDV), a modification was made to the funding arrangement with the establishment of NIRSAL (F4/GOS) by FMARD and the Banker's Committee of the Central Bank of Nigeria (F7/LEG). The new body replaced FMARD as a guarantor (F5/MKT). An Input Lending Framework (2013-2016) financing and guarantee agreement were set up, giving agro-dealers access to \$300 million through commercial banks (F6/RES). This led to the switching of the terms of financing

to front-ending (F5/MKT), thereby placing the responsibility for repayment with the agro-dealers and reducing the discomfort of the banks. Loans were capped at an 18% interest rate, which includes NIRSAL's 1% administration fee. Upon the timely completion of loan repayment, agro-dealers then claim 50% of the interest, implying that the actual interest was 9% with NIRSAL providing an interest rate subsidy of 50% (F5/MKT). The guarantee remained 75% of the loan's principal and interest accrued. NIRSAL set a 10-day window to attend to loan requests (F4/GOS). This enhanced the system's efficiency and further increased the trust in the Scheme among the stakeholders, especially the banks (F4/GOS). As a result, lending grew to \$125 million in 2013 through 113 loans dispersed by 13 commercial banks (F6/RES). In addition, the commercial banks requested an increase in the lending cap for agro-dealers from \$2 million to \$5 million and offered to double the loan period to 12 months (F5/MKT). As a result, loan projection for agriculture was expected to grow to \$250 million in 2014 (F4/GOS). Despite this, most agro-dealers, primarily SMEs, were unable to access funding from the banks (-F6/RES), attributed to stringent conditions for accessing loans such as a 10% equity requirement (-F5/MKT). Instead, they utilised informal contractual relationship with input suppliers (F4/GOS) to source their inputs. To enhance the operations of the Scheme, the Federal government announced new initiatives. These are the allocation of funds to develop the capacity to regulate fertiliser quality through sampling and laboratory testing (F6/RES; F3/KDF)), establishment of a new payment platform, the Nigeria Agriculture Payment Initiative (NAPI) (F4/GOS), and expansion of the GES scheme to help farmers access tractor hiring services (F4/GOS). Smart cards were issued to about 1 million farmers under NAPI to tackle the challenges of redemption in rural areas (F6/RES). The beneficiaries were, however, low compared to over 5 million registered farmers.

By 2014, the enthusiasm of key stakeholders in the Scheme had improved due to increased trust (F4/GOS), the success of rollout in previous years (F4/GOS) as well as a continuous learning process (F2/KDV). These led to the introduction of innovations to solve the challenges encountered in the first two years of rollout. As observed in the first two years of rollout, the challenges of low ownership of mobile phones among farmers and poor telephone networks in rural areas made it challenging to identify farmers uniquely, a central theme of the programme. Therefore, NAPI was piloted in Kogi and Zamfara States (F1/ENT). To successfully implement NAPI, the elaborate method of using OMR forms for registration adopted in 2013 was shelved to allow for the use of a simple enumeration form (R6/RES). This was based on feedback and a review of registration from the first two years of rollout (K2/KDV). This allowed NIMC to capture the biometrics of farmers for unique identification (F1/ENT). NAPI was also aimed at enhancing financial inclusion among rural farmers who were largely unbanked (F8/EXT). The slow pace of rollout of NAPI cards (-F6/RES) however made FMARD stick with the existing farmers' registration and inputs' redemption system.

Further review of the programme was undertaken to enhance its efficiency (F2/KDV). The 100% subsidy on seeds was reduced to 90% (-F6/MKT). To reduce operational costs, the role of SCM was reverted from the private sector to FMARD officials (-F2/KDV; -F4/GOS). The Scheme continued to witness improved performances. At the end of 2014, the number of redeemed certified seeds grew to 92,025mt, valued at 20.2b Naira. This was redeemed by 6,853,133 farmers in 36 States and the FCT. The number of seed companies participating under the scheme also grew from 45 in 2013 to 99 in 2014 (F1/ENT). In addition, global seed industry leaders such as Syngenta, Seed Company West Africa, Monsanto and DuPont-Pioneer commenced operations in or returned to Nigeria (F8/EXT). Credit facilities to the seed sector also increased from 1.8b Naira in 2012 to 4.2b Naira in 2013 and 6.0b Naira in 2014 (F6/RES). These represent an increase of 42.8% and 69.7% for 2013 and 2014, respectively. The high volume of feedback and requests led to the establishment of the GES Service Charter and Complaint Mechanism (F4/GOS). It handled complaints from various stakeholders involved in implementing the GES Scheme (F2/KDV). The Service Charter spelt out the roles, responsibilities, and expectations of stakeholders participating in the GES scheme (F4/GOS). To handle the complaints under the Service Charter, a Complaint Desk was set up (F4/GOS), with the average time to resolve complaints at seven days (F4/GOS). As a result, 576 complaints were received, out of which 390 were resolved (F1/ENT). To improve the integrity of the GES system, Consult Hyperion and the African Fertiliser and Agribusiness Partnership (AFAP) were commissioned by DFID to review the GES scheme (F2/KDV). The outcome led to the introduction of the Token Administration Platform (TAP) technology (F6/RES) which was piloted (F1/ENT) in partnership with the IFDC (F7/LEG) in Sokoto State and FCT between March and September 2014. The technology was used to register over 500,000 farmers and deploy 1.2 million e-wallets valued at over US\$19 million (F1/ENT). Despite these, signs began to emerge that the Scheme was running into troubled waters. This resulted from a sharp and steady decline in the price of crude oil in the international market, the mainstay of government revenue. This led to the downward review in the appropriation for the GES in 2015 by about 40 percent in nominal terms (-F6/RES).

Episode 3: Analyses of the trend and interaction patterns

The findings shown in Figure 11 indicate that F6/RES, F4/GOS and F5/MKT are the most dominant functions in the episode, while entrepreneurial activities (F1/ENT) continue to play an essential role. The scaling episode is similar to the emergent episode, the only difference being the scale and intensity of activities. The rise of the knowledge development (F2/KDV) function was also noticeable. Continuous monitoring, learning and evaluation role of the government necessitates a need to regularly intervene through the introduction of new technologies and other non-technological innovations (F6/RES) as well as the creation of institutions and agencies (F4/GOS) to tackle emerging challenges

and enhance efficiency. Further analysis reveals that the most given functions by actors were F4/GOS, F1/ENT, F5/MKT, mostly by government while F6/RES, F4/GOS, F5/MKT and F1/ENT were the most received functions (Figure 12), largely by smallholder farmers and agro-dealers (Figure 13). Similarly, F2/KDV and F6/RES were the functions that were mainly participated by actors. However, differences occurred in the F5/MKT and F6/RES functions where the financial institutions, especially NIRSAL, the new financial support vehicle, performed a significant given role. Another important consideration is the given role of the suppliers in generating externalities F8/EXT. This arises from the entrance of new firms and suppliers, especially international seed and fertiliser companies, as well as growth in seed companies due to a positive rating of the scheme.

As noted earlier, the activities in the scaling episode are similar to those of the second episode; hence, they exhibit similar characteristics. One difference is the deepening of the creation of appropriate structures that enhance the rapid diffusion and high intensity of the activities of entrepreneurs in the GES market. The episode can therefore be termed a market motor (Figure 14). The learning process was primarily driven by experience and feedback from key actors in the GES. These establish the importance of the DUI mode of learning in the BoP market. Different structural changes were made in implementing the programme with local and international support (F6/RES). These resulted in positive spillover effects (F8/EXT) on other actors in the GES.

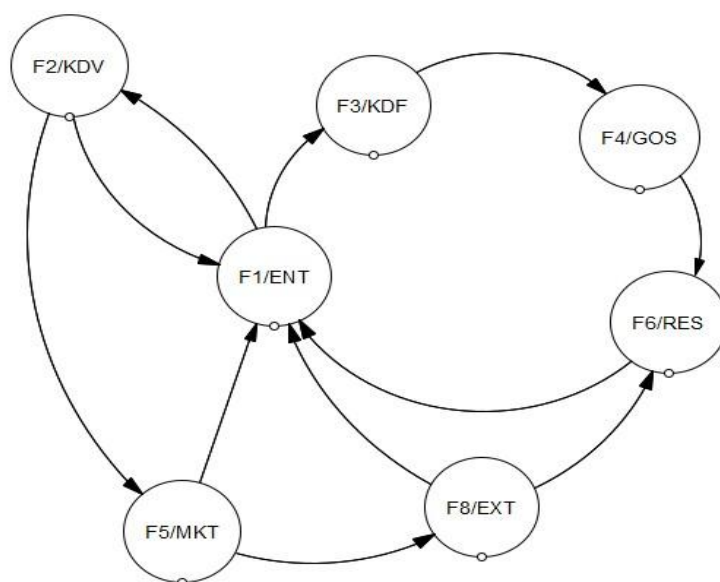
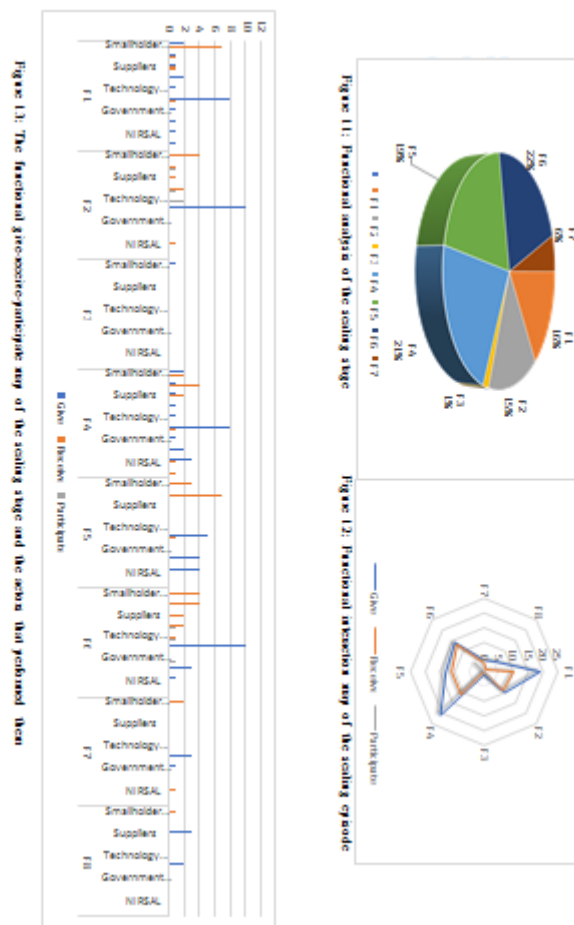


Figure 14: Functional dynamics of episode 3 – market motor

1.4.2.4. Episode 4: Uncertainty Suspension and Final Termination (2015 – 2018)

The programme gained international recognition with many African countries, including Malawi, Tanzania, Kenya, and Uganda, sending representatives to

understudy it (F8/EXT). The World Bank, early in 2015, approved the GES for all developing countries requiring its assistance to grow agriculture in their respective countries (F8/EXT). At home, there was a high clamour from all stakeholders, particularly the National Assembly and farmers, to institutionalise the GES Scheme (F2/KDV; F7/LEG). Arising from this, a draft bill for an Act to establish the GES Scheme was developed (F4/GOS). However, the bill was not passed into law (-F4/GOS). Consequently, the Scheme entered a period of uncertainty that threatened its continuation after years of consistent success. Two factors were responsible for this: a decline in government revenue because of a crash in global crude oil prices and change of government. The decline in revenue led to the failure of government to meet its obligations, with State governments reneging on payment of their counterpart funding of 25% subsidy for fertiliser (-F5/MKT). This results in accumulated backlog of unpaid debts to fertiliser and other input companies, running into billions of Naira (-F6/RES). Following this, several suppliers of inputs withdrew from the programme. The Federal Government estimated the outstanding subsidy in 2015 on fertiliser alone to about 67bn Naira (- F5/MKT). This resulted in the withdrawal of subsidy on fertiliser and subsequently suspension of the programme (-F5/MKT; -F1/ENT).

Consequently, the new Buhari administration suspended the Scheme and set up a committee to review it (F2/KDV). After the review, and arising from pressure from stakeholders (F7/LEG), the Federal Government made a volte-face and reintroduced the scheme (F1/ENT). The House of Representatives also called on the Federal Government to implement the 2017/2018 dry season GES (F7/LEG). The pressure led to the renewal of the contract of the technology developer, Cellulant (F6/RES), for additional two years, January 2015 – December 2016 (F4/GOS). The Scheme was also modified to address the challenges that made it unsustainable (F4/GOS) including strict adherence to online verification of farmers before redemption, thereby eliminating the use of manual register (F1/ENT). This was done to stop some of the alleged cases of corruption associated with the scheme. In addition, subsidy on seeds was further reduced from 90% to 75%, with farmers paying 25% of the total cost of seeds (-F5/MKT). In addition, redemption centres were replaced with agricultural input centres to create a cluster of agro-dealers close to farmers (F4/GOS) and deploy the use of using Point of Sales (POS) devices (F6/RES). Despite these, the Scheme was never again implemented on a large, national scale. The Federal Government only reintroduced the GES for the 2016/2017 dry season farming in 30 states of the country (F1/ENT) instead of the wet season farming, which usually has higher participation of actors. The Minister of State for Agriculture, Heineken Lokpobiri, undertook the flagging-off ceremony in Kano in February 2017 (F3/KDF). The inputs targeted 500,000 farmers but achieved a 92% success rate (F4/GOS) by distributing inputs to 458,498 farmers between December 2016 and February 2017 (F1/ENT). The Federal government paid the 50% subsidy on fertiliser and 75% on seeds.

Stakeholders, including the National Coordinator, Zero Hunger Commodities Association (/F7LEG), commended the programme's reintroduction. In addition, the programme continued to win accolades locally and globally (F8/EXT), leading to the engagement of Cellulant by the governments of Liberia and Afghanistan to develop a similar programme (F8/EXT).

Despite the government's promise to continue the programme, it was stopped with an announcement by the Minister in May 2018 (-F1/ENT). Several stakeholders continued to call for the return of the GES Scheme, even after its formal scrapping. For instance, women farmers under the umbrella of the Small-Scale Women Farmers Organisation in Nigeria (SWOFON) called for the restoration of the Scheme (F7/LEG). At the same time, the President of the All Farmers' Association of Nigeria (AFAN), on a visit to the new Minister of Agriculture and Rural Development, Alhaji Muhammad Sabo Nanono, in March 2020, also appealed for the government to revisit and fine-tune the programme, which he believes would boost farmers production, create jobs and increase internally generated revenue (F7/LEG). Different stakeholders locally and internationally made several efforts to resuscitate the programme but all to no avail. The Ondo state government also planned to introduce a similar initiative in the state in 2020 (F1/ENT) while the African Development Bank (ADB) requested an Expression of Interest for a "consultant to support the implementation of a National Agricultural Input Support Scheme (NAISS) in Nigeria" (F6/RES).

Episode 4: Analyses of the trend and interaction patterns

The analysis of the final episode reveals the dominance of F7/LEG and F6/RES. There was also a reflection of positive externalities F8/EXT (Figure 15). Contrasted to the preceding scaling episode, this stage was characterised by low level of entrepreneurial activities F1/ENT, especially smallholder farmers and government, as well as a low level of target-setting, standardisation and expectations (F4/GOS). The functional interaction analysed through the give-receive-participate framework indicates that the function given mostly by actors was F7/LEG while the most received functions were F7/LEG and F6/RES (Figure 16). The Federal Government continued to be the primary 'giver' of the other functions; intermediaries played the given role in the F7/LEG with the government the main receiver (Figure 17). Two paths can be mapped out (

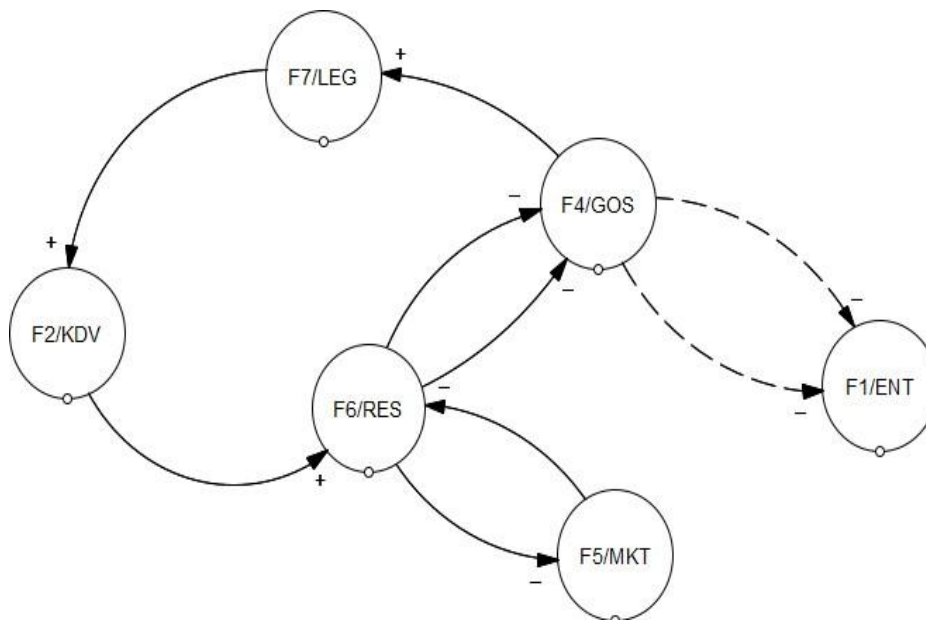


Figure 18). First, the decreased funding (-F6/RES) led to unfulfilled promises in terms of payment of subsidy (-F4/GOS), which led to a reduction in entrepreneurial activities with the stoppage of supply of inputs by the different companies (-F1/ENT). These resulted in the subsequent suspension of the Scheme in 2015 (-F1/ENT). The second path can be traced to 2015, with the new administration continuing to make promises of continuation with the Scheme (F4/GOS), which was reflected in the new government policy for the agricultural sector, the Agricultural Promotion Policy (F4/GOS). Coupled with increased advocacy for the return of the Scheme (F7/LEG), and review (F2/KDV), leading to the reintroduction of the Scheme in 2016. Resources were provided by the Federal government alone (F6/RES), with new operational guidelines that emphasised the reduction in scope and scale (F5/MKT). This however failed to guarantee market formation (-F5/MKT) as many stakeholders were sceptical of government plans (-F4/GOS) and failed to participate in the Scheme (-F1/ENT) leading to a reduction in entrepreneurial activities (- F1/ENT) and subsequent termination of the programme in 2018 (-F1/ENT). The rise in lobbying and advocacy by intermediaries was aimed at protecting the interest of their members, especially smallholder farmers and agro-dealers. This episode can thus be described as a motor of decline - cumulative causation resulting in a standstill and later complete termination of the Scheme.

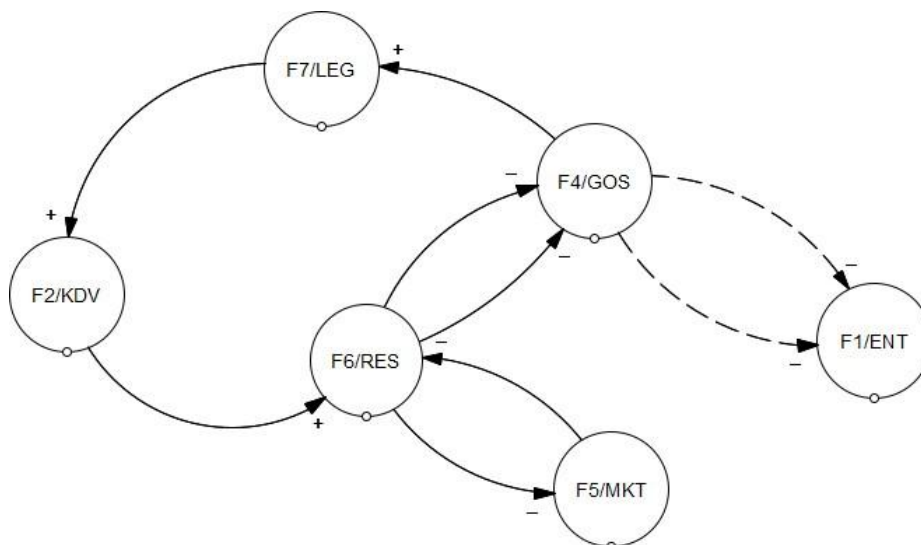
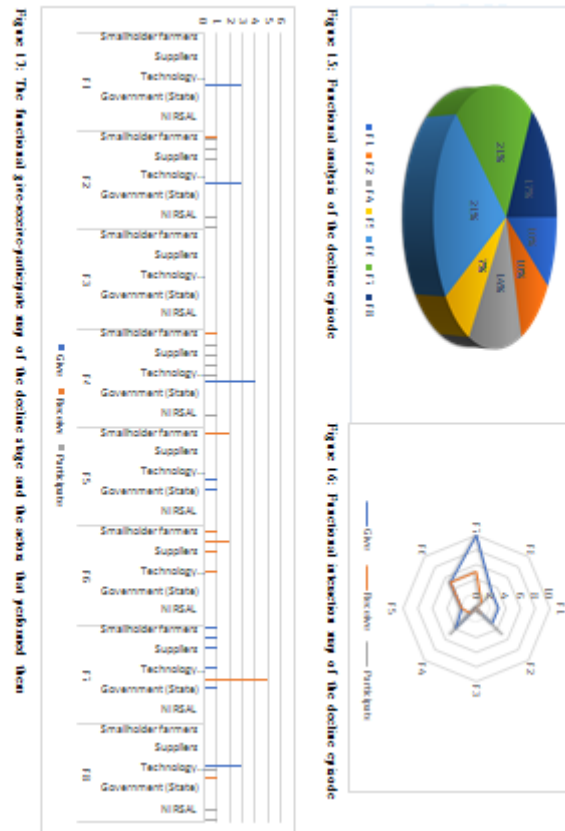


Figure 18: Functional dynamics of episode 4 – the motor of decline

1.5 CONCLUSION AND RECOMMENDATIONS

In this study, we further demonstrate the applicability of the EHA as a tool to evaluate the functional dynamics and performance of an IS aimed at inclusive development. We identified the role of functions driving the dynamics of the GES scheme and show how they reinforce one another to create the cumulative

causation and motors in the different episodes. This complements the study by Maarsingh et al. (2021), the only study to date which utilized the EHA methodology to assess the functional dynamics in the case of ICT4D in South Africa. We however expanded this by introducing the demand-pull motor which captures the peculiarities of the I4IDS and also the give-receive-participate framework. This enables us to assess the role of different actors in the fulfilment of the different functions. Through this, we deepen the understanding of functional dynamics in the evolution of ISs. This approach gives us insight into the inner processes in the IS thereby allowing us to assess the strength and weaknesses of the evolution of the system.

Findings from the EHA show that the dynamics of I4IDS may be unsmooth, bumpy and unpredictable, necessitating continuous monitoring, evaluation and learning. Within the I4IDS context, government plays this important role, through interventions in the form of policies, institutions, and new structures that aid the system's evolution. The main inducement factors of the GES scheme were exogenous, driven by high crude oil price, high food imports, market opportunities and new political leadership. Blocking mechanisms included economic recession arising from the crash in crude oil prices leading to a massive drop in government revenue and change in political leadership in the country. These led to the inability of the government to meet the subsidy obligations, leading to mounting debts to suppliers and eventually termination of the Scheme.

Four motors were identified in the study: demand-pull, entrepreneurial, market, and motor of decline. An observation from the study is that the functions driving the dynamics of an I4IDS may vary in different episodes of the GES leading to the development of different motors for each episode. For example, in the first episode (2011), guidance of the search was the main driver, catalysed by the Federal Government. The objective was to develop policy guidelines, develop institutions, build trust, and buy-in of the different stakeholders to enable the diffusion of the system. Because of the perceived unprofitability of the BoP market, government played a central role in driving ISs in development context. The demand-pull motor was therefore established. The second and third episodes which lasted for a period of 3 years (2012–2014) were characterized by virtuous cycles leading to the establishment of the entrepreneurial and market motors. The second episode was essentially an entrepreneurial motor driven by four functions: entrepreneurial activities, resource mobilization, guidance of search and knowledge diffusion. At the heart of this episode is the government playing a central role in enabling the rollout of inputs by building a coalition, engaging different stakeholders, and mobilising financial, technological and human resources to enhance the rapid diffusion of the Scheme. The third episode was similar to the second, however, with a higher intensity of entrepreneurial activities, and the fulfillment of the other functions except creation of legitimacy. The episode also witnessed the

manifestation of the positive externalities function in form of local and international recognition, entrance of new companies from abroad, creation of new industries, and the seizing of new opportunities by existing actors. These further assisted in improving entrepreneurial activities, market formation and resource mobilization leading to the establishment of the market motor. The final episode was characterized by uncertainty, suspension and final termination of the programme (2015 - 2018). From 2015, the programme entered a period of uncertainty arising from the inability to mobilise resources, creating a vicious cycle that led to its final termination in 2018.

The EHA of the GES Scheme has shown that with strong institutions, an IS built around inclusive development can be implemented in a manner that meets the needs of the marginalized. We identify the role of institutions in driving the functional dynamics of the GES scheme. Balancing the implementation of demand-side and supply side policies in a way that complements the evolution of the GES scheme is important for policy. These become more important in the context of I4IDS, where government plays an important role in implementing policies needed to incentivize private-sector participation in BoP markets which are usually considered unprofitable (Prahalad & Hammond, 2002). The study also demonstrates that for I4IDS to succeed, policy should take a holistic approach by addressing not only institutional and network failures but also market failures (Carlsson and Jacobsson, 1997).

Based on our analyses, we make some recommendations. First, reliance on government as the sole funder of large-scale interventions for I4IDS, especially in most developing economies, seems to be unsustainable. The inability to withstand shocks e.g. from distortions in the price of primary commodities could negatively influence the way functions are performed. In the case of the GES, this affected resource mobilisation, market formation, entrepreneurial activities and creation of legitimacy functions, adversely affecting I4IDS programmes. Heterodox solutions that emphasise diversified funding for I4IDS programmes and competition from suppliers should be implemented.

Second, in implementing innovation activities in developing economies, informal institutions have been found to play a complementary role to strong formal institutions or substitute weak formal institutions in the absence or presence of firm-level resources. In addition, weak informal institutions can also accommodate strong formal institutions in implementing innovations (Saka-Helmhout et al., 2020). The challenge for policy supporting the I4IDS is to have a deeper understanding of the interactions between formal and informal institutions to create multiple paths to innovations in the BoP market.

Finally, the role of government in driving I4IDS should focus on strengthening three system functions: guidance of the search, market formation and resources mobilisation. Guidance of the search to develop a critical mass that can drive successful diffusion; market formation to

enable through appropriate institutional interventions that can enhance monitoring and evaluation learning, and resource mobilization to create a heterodox source of funds that can withstand economic shocks and thereby guaranteeing long-term sustainability.

References

- Adebo, G. M. (2014). Effectiveness of E-Wallet Practice in Grassroots Agricultural Services Delivery in Nigeria - A Case study of Kwara State Growth Enhancement Support Scheme. *Journal of Experimental Biology and Agricultural Sciences*, 2(4), 410–414.
- Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy*, 37(3), 407–429. <https://doi.org/10.1016/j.respol.2007.12.003>
- Bergek, A., Jacobsson, S., & Sandén, B. (2008). 'Legitimation' and 'development of positive externalities': Two key processes in the formation phase of technological innovation systems. *Technology Analysis & Strategic Management*, 20(5), 575–592.
- Cassiolato, J. E., Pessoa de Matos, M. G., & Lastres, H. M. M. (2013). Innovation Systems and Development. <https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/51575/IDL-51575.pdf?sequence=1>
- Cozzens, S. E., & Sutz, J. (2012). Innovation in Informal Settings: A Research Agenda Executive Summary Innovation in Informal Settings: A Research Agenda. IDRC.
- De Oliveira, L. G. S., & Negro, S. O. (2019). Contextual structures and interaction dynamics in the Brazilian Biogas Innovation System. *Renewable and Sustainable Energy Reviews*, 107, 462–481. <https://doi.org/10.1016/J.RSER.2019.02.030>
- Egbetokun, A., Oluwadare, A. J., Ajao, B. F., & Jegede, O. O. (2017). Innovation systems research: an agenda for developing countries. *Journal of Open Innovation: Technology, Market, and Complexity*, 3(4), 1–16. <https://doi.org/10.1186/S40852-017-0076-X>
- Federal Ministry of Agriculture and Rural Development. (2011). Agricultural Transformation Agenda: We Will Grow Nigeria's Agricultural Sector.
- Gault, F. (2010). Innovation Strategies for a Global Economy: development, implementation, measurement and management. Edward Elgar Publishing.
- GrowAfrica. (2016). Fertilizer Subsidy Reform Revives Nigeria's Agriculture.
- Hacking, N., Pearson, P., & Eames, M. (2019). Mapping innovation and diffusion of hydrogen fuel cell technologies: Evidence from the UK's hydrogen fuel cell technological innovation system, 1954–2012. *International Journal of Hydrogen Energy*, 44(57), 29805–29848. <https://doi.org/10.1016/J.IJHYDENE.2019.09.137>
- Hannon, M. J., Foxon, T. J., & Gale, W. F. (2015). 'Demand pull' government policies to support Product-Service System activity: the case of Energy Service Companies (ESCos) in the UK. *Journal of Cleaner Production*, 108, 900–915.
- Heeks, R., Amalia, M., Kintu, R., & Shah, N. (2013). Inclusive Innovation: Definition, Conceptualisation and Future Research Priorities (No. 53; Development Informatics Working Paper).

- Hekkert, M. P., & Negro, S. O. (2009). Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims. *Technological Forecasting and Social Change*, 76(4), 584–594. <https://doi.org/10.1016/j.techfore.2008.04.013>
- Hekkert, M., Suurs, R. A. A., Negro, S., Kuhlmann, S., & Smits, R. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change*, 74(4), 413–432. <https://doi.org/10.1016/j.techfore.2006.03.002>
- Hermans, F., Geerling-Eiff, F., Potters, J., & Klerkx, L. (2019). Public-private partnerships as systemic agricultural innovation policy instruments – Assessing their contribution to innovation system function dynamics. *NJAS - Wageningen Journal of Life Sciences*, 88, 76–95. <https://doi.org/10.1016/J.NJAS.2018.10.001>
- Jacobsson, S., & Bergek, A. (2006a). A framework for guiding policy-makers intervening in emerging innovation systems in ‘catching-up’ countries. *The European Journal of Development Research*, 18(4), 687–707. <https://doi.org/10.1080/09578810601094902>
- Jacobsson, S., & Bergek, A. (2006b). A framework for guiding policy makers intervening in emerging innovation systems in ‘catching up’ countries. *European Journal of Development Research*, 18(4), 687–707.
- Kraemer-Mbula, E., & Watu, W. (2010). *Innovation and the Development Agenda*. International Development Research Centre, Organisation for Economic Co-operation and Development.
- Lizuka, M. (2013). Innovation systems framework: still useful in the new global context?(#2013-005).
- Lizuka, M., & Gebreeyesus, M. (2017). Using Functions of Innovation Systems to Understand the Successful Emergence of Non-traditional Agricultural Export Industries in Developing Countries: Cases from Ethiopia and Chile. *The European Journal of Development Research*, 29(2), 384–403. <https://doi.org/10.1057/s41287-016-0004-0>
- Maarsingh, B. (2022). Exploring the dynamics of inclusive innovation systems through event history analysis [Stellenbosch: Stellebosch University]. <https://scholar.sun.ac.za:443/handle/10019.1/124586>
- Maarsingh, B., Grobbelaar, S. S., Uriona-Maldonado, M., & Herselman, M. (2021). Exploring functional dynamics of innovation for inclusive development: event history analysis of an ICT4D project. *Innovation and Development*, 0(0), 1–31. <https://doi.org/10.1080/2157930x.2021.1956712>
- Mackintosh, M., Chataway, J., & Wuyts, M. (2007). Promoting innovation, productivity and industrial growth and reducing poverty: Bridging the policy gap. *European Journal of Development Research*, 19(1), 1–12. <https://doi.org/10.1080/09578810601144202>
- Minot, N., & Benson, T. (2009). *Fertilizer Subsidies in Africa: Are Vouchers the Answer?*(Brief 60; Issue May 2014).
- Nagy, J. G., & Edun, O. (2002). *Assessment of Nigerian Government Fertilizer Policy and Suggested Alternative Market-Friendly Policies* (Issue September).

- Negro, S. O. (2007). Dynamics of Technological Innovation Systems – The case of Biomass Energy. Utrecht University.
- Negro, S. O., Hekkert, M. P., & Smits, R. E. (2007). Explaining the failure of the Dutch innovation system for biomass digestion-A functional analysis. *Energy Policy*, 35(2), 925–938. <https://doi.org/10.1016/j.enpol.2006.01.027>
- Nemet, G. (2009). government-led incentives for non- incremental technical change. *Research Policy*, 38, 700–709. <https://doi.org/10.1016/j.respol.2009.01.004>
- Nwuke, K. (2021). Nigeria's Petroleum Industry Act: Addressing old problems, creating new ones. <https://www.brookings.edu/blog/africa-in-focus/2021/11/24/nigerias-petroleum-industry-act-addressing-old-problems-creating-new-ones/>
- OECD. (2015). Innovation policies for inclusive development: scaling up inclusive innovations. 39. <https://doi.org/http://dx.doi.org/10.1787/9789264229488-en>
- Onyekwena, C., Adeniran, A., Onubedo, G., Bodunrin, S., & Ishaku, J. (2018). Digital Technology and Fertilizer Reforms in Nigeria.
- Paunov, C. (2013). Innovation and Inclusive Development. In OECD Publishing. <https://doi.org/10.1787/5k4dd1rvsnjj-en>
- Prahalad, C. K., & Hammond, A. (2002). Serving the world's poor, profitably. *Harvard Business Review*, 80(9), 48. <https://doi.org/10.1108/02756660710732611>
- Reichardt, K., Negro, S. O., Rogge, K. S., & Hekkert, M. P. (2016). Analyzing interdependencies between policy mixes and technological innovation systems: The case of offshore wind in Germany. *Technological Forecasting and Social Change*, 106, 11– 21. <https://doi.org/10.1016/J.TECHFORE.2016.01.029>
- Saka-Helmhout, A., Chappin, M., & Vermeulen, P. (2020). Multiple Paths to Firm Innovation in Sub-Saharan Africa: How informal institutions matter. *Organization Studies*, 41(11), 1551–1575. <https://doi.org/10.1177/0170840619882971>
- Suurs, R. A. A. (2009). Motors of Sustainable Innovation - Towards a theory on the dynamics of technological innovation systems. Universiteit Utrecht.
- Suurs, R. A. A., & Hekkert, M. P. (2009). Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands. *Technological Forecasting and Social Change*, 76(8), 1003–1020. <https://doi.org/10.1016/J.TECHFORE.2009.03.002>
- Suurs, R. A. A., Hekkert, M. P., Kieboom, S., & Smits, R. E. H. M. (2010). Understanding the formative stage of technological innovation system development: The case of natural gas as an automotive fuel. *Energy Policy*, 38(1), 419–431. <https://doi.org/10.1016/j.enpol.2009.09.032>
- Uriona, M., & Grobbelaar, S. S. S. (2018). Innovation System Policy Analysis through System Dynamics Modelling : A Systematic Review. *Science and Public Policy*, April, 1–17. <https://doi.org/10.1093/scipol/scy034>
- van de Ven, A. H. (1992). Suggestions for Studying Strategy Process: A Research Note. *Strategic Management Journal*, 13, 169–188.

- van de Ven, A. H., & Poole, M. S. (1995). Explaining Development and Change in Organizations. *The Academy of Management Review*, 20(3), 510–540.
- Vroon, T., Teunissen, E., Drent, M., Negro, S. O., & van Sark, W. G. J. H. M. (2022). Escaping the niche market: An innovation system analysis of the Dutch building integrated photovoltaics (BIPV) sector. *Renewable and Sustainable Energy Reviews*, 155, 111912. <https://doi.org/10.1016/J.RSER.2021.111912>
- Wieczorek, A. J., & Hekkert, M. P. (2012). Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. *Science and Public Policy*, 39(1), 74–87. <https://doi.org/10.1093/scipol/scr008>

Social Enterprises in Malaysia: Understanding Typology, Ecosystem and Sustainability

Angathevar Baskaran, Theresa S.Y.Chan. VGR Chandran

Department of Development Studies, Faculty of Business and Economics, & UM North-South Research Centre, University Malaya, Malaysia

Sonia Kumari Selvarajan

Department of Development Studies, Faculty of Business and Economics, University Malaya, Malaysia

Abstract

This paper explores the social enterprises' typology, configurations, the ecosystem domains, and the factors contributing to their sustainability including major challenges faced in Malaysia. The paper employs qualitative research approach and primary data gathered from 20 social enterprises across four regional clusters using semi-structured interview. The findings indicate that emergence of social enterprises in Malaysia are via the venture of corporate and business experienced founders over 30 years of age who mainly operates in niche or exclusive market. Most social enterprises largely configure as hybrid organisations combining commercial and social welfare logics. While well-established social enterprises have adequate staffing and resources, others mainly use volunteers on ad-hoc basis from the beneficiary communities, universities, NGOs, and foreign countries. The financing domain of the ecosystem seems to suggest that at initial stage personal investment drive the formation of social enterprise, and when the enterprise progresses other sources of financing such as seed funding (from accelerators or incubators), business angels, grants from private foundations, and corporate sponsorship becomes essentially important. Self-discovery process drives the social enterprise sustainability, which is largely subjected to their business management ability to access market. The founders become the critical drivers of the social enterprises' sustainability. The main challenge, for both rural and urban social enterprises, is scepticism among beneficiary communities and gaining credibility in the market due to lack of public awareness. Additionally, there are challenges in obtaining legal recognition

Key Words: Social enterprise, Social entrepreneurship, Entrepreneurship ecosystem, Malaysia.

1. Introduction

Social entrepreneurship is defined as services to satisfy basic human needs, particularly those that contribute to health and education, which are failing poor people in terms of access, quality, and affordability (World Bank, 2003). The development of social entrepreneurship has been spurred by global wealth disparity; movement of corporate social responsibility; market, institutional and state failures; technological advances and shared responsibility (Jiao, 2011). With growing global economic uncertainties and concerns about climate change, interest among practitioners, policymakers and academics on social entrepreneurship has been increasing globally (Kelley et al., 2016; Bielefeld, 2009; Kadir & Sarif, 2016). This is also evident in Malaysia. However, given that the very logic of promoting social enterprises are to harness social impacts, wrong policy configuration could lead to similar fate as microfinance models where conflict arise between the profit and welfare logics. This requires us to further understand the nature and the ecosystem of the social enterprises for policy inputs.

In 2015, the Malaysian Global Innovation & Creativity Centre (MaGIC), a government owned entity, formulated a blueprint to develop the social enterprise ecosystem (MaGIC, 2015). Gathering feedbacks from existing industry players, the blueprint highlighted notable challenges faced by social enterprises: (i) Rigidity and lack of institutional awareness (ii) Lack of legal recognition and policy structure to support; (iii) Negative public perception and recognition; (iii) Lack of access to quality human capital; (iv) Lack of support to grow and scale-up. Other intermediaries such as Tandemic, MyHarapan, and Air Asia Foundation have been fostering social entrepreneurship in the country (Baskaran et al., 2019). In 2018, a survey of 132 social enterprises was commissioned by the British Council and supported by United Nations ESCAP and Yayasan Hasanah “to map the Malaysian social enterprise landscape and to identify key opportunities and issues that need to be addressed to create a healthy and sustainable ecosystem for social enterprises to thrive” (British Council et al., 2018). In November 2019 the government came up with Social Enterprise Accreditation (SE.AC) Guidelines which “act as a guide to explain the definition, procedures, and criteria involved in the accreditation process and related matters” (Ministry of Entrepreneur Development, 2019, p. 2), and the first group of 22 social enterprises have received the SE.AC in January 2020. This includes 5 social enterprises that participated in this study (APE Malaysia; Biji Biji, EPIC Homes, Tanoti and WormingUp). Subsequently, the ministry has introduced Basic Social Enterprise (SE.ASAS) registration for those who are not able to apply for SE.A. It released the Malaysia Social Entrepreneurship Blueprint 2030 (SEMy2030 in April 2022) , “which is designed to create a

cohesive and holistic ecosystem supportive of the growth of social entrepreneurship in the country” (MEDC, 2022).

Since 2019, MaGIC has introduced a number of programmes to promote social entrepreneurship including Pemangkin Usahawan Sosial Hebat (PUSH) which is a scale-up programme focused on a personalised capacity building and skills development training, Social enterprise mentorship, Buy for Impact (promoting goods and services of social enterprises). Recently, the National Institute of Entrepreneurship Berhad (INSKEN) has started promoting social entrepreneurship through training programmes.

Although there was an initial effort led by British Council and Ministry of Entrepreneur Development and UN ESCAP in 2018 involving 132 respondents, some in depth interviews, and round table of stakeholders towards mapping social entrepreneurship landscape in Malaysia, still there is no comprehensive understanding of various elements of the mapping of social entrepreneurship ecosystem in Malaysia. One of the major hurdles was the absence of formal legal recognition of the sector until early 2020. Because of this, there is no source of information from where researchers can access quantitative and qualitative data on the social enterprises in Malaysia. There is no clear picture of various actors, activities, linkages between them and the absence of linkages between them in the ecosystem. There is no serious research on typology of social enterprises, key domains of ecosystem such as market, finance, human capital, culture, support, and policy, sustainability factors, and the impact of measurement of social entrepreneurship. This research attempts to address some of these knowledge deficits in this sector.

The existing research studies on social entrepreneurship are limited (Said et al., 2015), which mainly focus on outcomes of specific programmes, selected segments and contributing factors. For instance, Hulme (1990) only reported the outcome of microcredit on poverty alleviation in Selangor. Othman & Wahid (2014) focuses on the role of personality traits in social entrepreneurship, while Nasruddin & Misaridin (2014) explored social enterprises operating as for-profit entities. Likewise, Zainon et al., (2014) examined social enterprises’ legitimacy and Said et al. (2015) studied the role of higher education in social entrepreneurship. Kadir & Sarif Malaysia.

The review of extant literature reveals that there is a knowledge gap on the actors and activities involved in the social enterprise ecosystem and linkages among them. In filling the research gaps, this study aims to investigate the following: (i) What are the major characteristics of social enterprises in Malaysia? (ii) How do the key domains of entrepreneurship ecosystem (market, finance, human capital, culture, support, policy) shape the social entrepreneurship?

(iii) What are the factors contributing to sustainability of social enterprises? (iv) What are the major challenges faced by the social enterprises in Malaysia?

2. Literature Review

2.1 Definition

Social entrepreneurship is a multidimensional construct (Mort et al., 2002); aimed at identifying a stable yet unjust equilibrium, and to forge a new socially equitable equilibrium (Martin and Osberg, 2007) by simultaneously pursuing both financial and social return on investment. Social entrepreneurs are change agents seeking transformational change (Dees, 1998, Waddock & Post, 1991); forming new activities or ventures to overcome market failures (Harding, 2004; Peredo and McLean, 2006, Leadbeater, 1997, Reis, 1999). There are different definitions because of a broad conception of social entrepreneurship and different types of social enterprises. However, all of them focus on a singular purpose – achieving social objectives. Social enterprises therefore employ (i) business tools to achieve social objectives;

(ii) a blend of social and commercial capital methods; (iii) creation of social and economic values; (iv) income from commercial activities to fund social programmes; (v) market-driven and mission-led approaches; (vi) financial performance and social impact measurements; and they aim to achieve (vii) financial goals while contributing towards public good; (viii) financial freedom from unrestricted income; and (ix) strategic enterprise incorporation towards mission accomplishment (Alter, 2007).

Only at the end of 2019, the government of Malaysia came up with a definition for social enterprise as: “Business entity that is registered under any written law in Malaysia that proactively creates positive social or environmental impact in a way that is financially sustainable” (Ministry of Entrepreneur Development, 2019, p. 4). As there was no legal definition of social enterprise in Malaysia at the time this research was started, we employed a modified definition as used by the UK Government:

“A social enterprise is a business [or organization] with primarily social objectives [which is run on business principles to generate revenues and surpluses], whose surpluses are principally reinvested for that purpose in the business or in the community, rather than being driven by the need to maximise profit for shareholders and owners” (DTI, 2004).

The Malaysian government appears to have arrived at this diluted definition to match the reality on the ground. As the social enterprises in Malaysia are registered as Sendirian Berhad (SDN BHD) -- private limited companies, trusts, societies, foundations, and non-government organizations (NGOs), it would create complex problems to introduce a new legal entity specific to social enterprise. Hence, the government chose to go for accreditation scheme rather than specific definition based legal framework. Since the introduction of the Social Enterprise Accreditation (SE.A) Guidelines at the end of 2019, the Ministry of Entrepreneur Development has assumed direct responsibility for promoting social entrepreneurship in the country.

2.2 Social Enterprise: Typology / Business Models

Using Alter's (2007) classification model, we can classify a social enterprise by its (i) mission orientation; (ii) business integration and operating model; and (iii) organisation structure. Mission orientation defines the purpose of the organisation. A social enterprise can be categorised either mission-centric, or mission-related, or mission-unrelated. In a mission-centric social enterprise, its activities and social mission are dependent and mission is central to the organisation purpose. In a mission-related social enterprise, the social mission is related to but not necessarily relevant to the organisation's entrepreneurial activity. Therefore, the social programme is integrated into the organisation's operation as a service-subsidising model. In a social enterprise that is unrelated to mission, the social programmes and enterprise operations are run independently and the enterprise's sole mission is to generate income for its social programmes and to meet operating cost. The business integration and operating model describes the level of integration of its social and commercial activities as either embedded, integrated or separately operated. The organization structure identifies whether a social enterprise is structured as a department, programme or profit center within a nonprofit or a subsidiary of its nonprofit parent, or registered as a for-profit or nonprofit entity.

Muller (2012, pp. 116-117) postulates specific components and principles of social enterprises' models: 1. Value proposition: create social value, cater to basic humanitarian and environmental problems, provide solutions for social problems, induce social change; 2. Value architecture: apply innovative resource mobilization strategies partnership, co-creation, volunteer support); 3. Revenue Model: employing various sources of money, revenue generating model to support social value creation, price differentiation. Schwab Foundation for Social Entrepreneurs (2011, p. 28) distinguishes three types of social enterprises based on their financial model: 1. Leveraged Nonprofit (which mostly depends on outside philanthropic money); 2. Hybrid Nonprofit (which combines non-profit approach and cost-recovery by selling goods and services); 3. Social Business (which generates revenue and profits and self-sustaining).

2.3 Sustainability

A social venture sustainability model is defined as "the process of creating, delivering, and capturing value for all stakeholders involved in the social venture" (Beugre', 2017, p. 110). The construct of social venture sustainability model (SVSM) includes following elements: specification of targeted stakeholders, definition of desired social profits (impacts) and social profit equation, economic profit equation targeting full recovery of costs and capital, not financial profit maximization (Beugre', 2017, p. 110).

A social entrepreneur requires a combination of entrepreneurial skills and social motivation (Dees and Anderson, 2003). A successful and sustainable

social enterprise relies on teams with shared values and combination of right skills (Haugh, 2005). Abu-Saifan (2012) identified seven common characteristics linked to social entrepreneurs (i.e. innovative, dedication, taking initiative, leadership, opportunity seeking, persistent, and strong commitment). Background of social entrepreneur such as education, previous experience and personal traits could have a significant influence on the sustainability and performance of the social enterprise.

2.4 Influencing Ecosystem

Table 1 shows the stakeholders or actors, development factors of the entrepreneurship ecosystem, their domains and key determinants, which are drawn from previous studies (Freeman, 2001; Alter, 2007; Pilinkienė & Mačiulis, 2014). The entrepreneurship ecosystem domain categories -- market, finance, human resource, culture, support and policy – are drawn from Babson Global Entrepreneurship Ecosystem model (Pilinkienė & Mačiulis, 2014).

<i>Development Factors</i>	<i>Ecosystem Domains</i>	<i>Key Determinants</i>	<i>Ecosystem Components (Existing)</i>	<i>Stakeholders</i>
Skilled People (Internal)	Human Capital	Entrepreneurial Capabilities	Intermediary	Entrepreneur Employees
Opportunities (External)	Market	Market Conditions	Intermediary, Public, Corporate/ Business	Beneficiaries Community Society
Resources (External)	Finance	Access to Finance	Public, Corporate/ Business	Related Organisational Entities
	Support	R&D and Technology	Intermediary, Public	Volunteers & Interns, Public, Beneficiaries
	Culture	Culture		
	Policy	Regulatory Framework	Government	Institutions

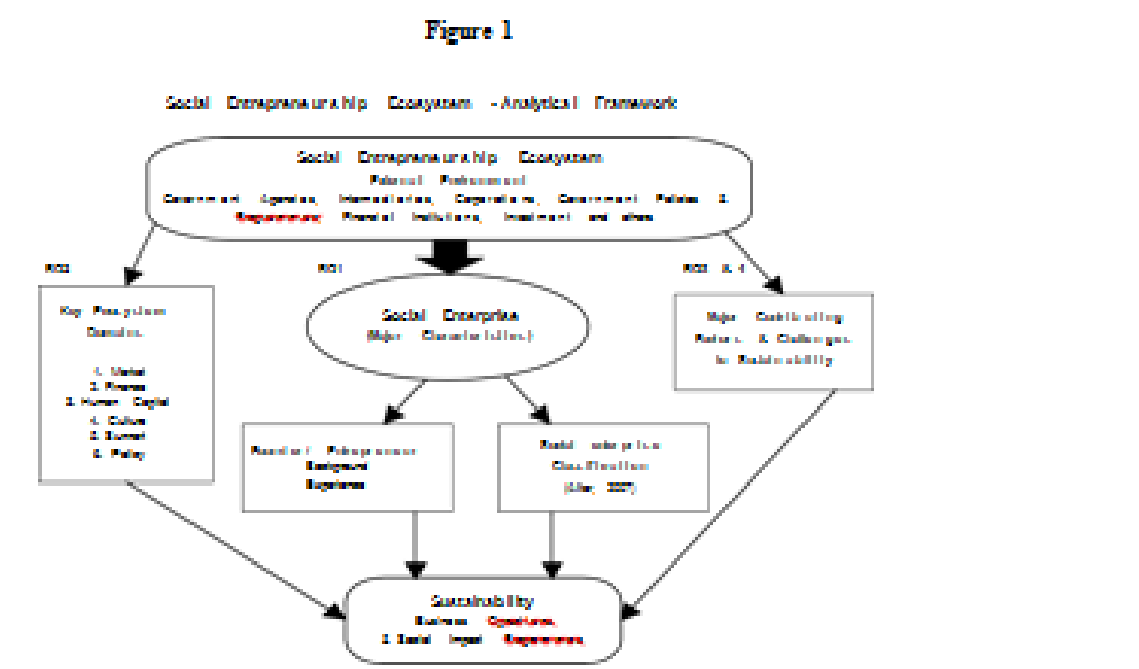
Source: Freeman (2001), Alter (2007), and Pilinkienė & Mačiulis (2014).

Drawing from the literature, Figure 1 presents an entrepreneurship ecosystem framework to analyse the data gathered from the sample social enterprises in Malaysia.

3. Research Methodology

As there is a lack of data required for any meaningful quantitative (positivist) research (Chua, 2012), this study adopts a qualitative exploratory research approach, that allows social constructivism and subjective interpretation. It uses primary data gathered from 20 social enterprises in four different regions: Klang Valley, Sabah, Sarawak and Penang (see Appendix 1). As there is no

formal recognition of this sector, the sample was randomly selected from the 200 social enterprises registered in the MyHati and MaGIC Startup database. The sample includes 3 NGOs that are transitioning to social enterprises. We gathered data using semi- structured (recorded) interviews that lasted about 60 to 90 minutes. The interviews were conducted in 2 phases. The first phase was completed between mid 2017 and mid-2018. The second phase was conducted in 2020 mainly to update the data on social impact. Other supporting information comes from secondary sources obtained from websites that helped validate the interview information.



Source: Drawn from Alter (2007), (Ahmad & Hoffman, 2008). Freeman (2001), and Pilinkienė & Mačiulis (2014) and others.

Table 2 depicts the profile of the interviewed social enterprises. All social enterprises espoused explicit social and/or environmental objectives. Most of them were initially started as a personal initiative, eventually evolving into an organized activity before incorporation. Most founders were over 30 years old when they set up their social enterprises and had professional qualifications and corporate/ business experience. Almost all are mission-centric, and their target beneficiaries include rural communities, women and children, school children and teachers, mentally challenged and hearing impaired. The sectors they operate include tourism, education, art and craft, public relations, agriculture, and waste management.

Table 2: Organisation Profile and Founders' Backgrounds of Sample Social Enterprises

No	Social Enterprise	Location	Est. Year	Legal/Ownership Structure	Products & Services	Number of staff	Founder Age	Founder Qualification	Professional Background
1	100% Projects	Malang, Valley	2013	Sondolan Soshad (SDN BHD) – Private Limited Company	Facilitating financial support for rural schools	3	>30	Law, IT, Psychology	IT, Consultant, Banker, Educationist
2	ANB Agro Trainer	Penang	2012	SDN BHD	Agro products & Services	>10	>30	Master IT	Manufacturing & Education
3	APE Malaysia	Malang, Valley	2007	SDN BHD	Environmental conservation, animal welfare services	3-10	>30	Bachelor	Conservationist & Environmental lobbyist
4	Alma Academy	Penang	2015	SDN BHD	Educational Services	3-5	<30	Actuarial Science, IT, Psychology & Engineering	Fresh graduate
5	Backyard Tours	Samudak	2013	SDN BHD	Rural eco-tour packages	>10	<30	Bachelor- TESOL & IT	Fresh graduate
6	Batik Boutique	Malang, Valley	2013	SDN BHD	Produce batik products	>10	>30	MBA, Engineering, Communication	Tourism, Manufacturing & Consultancy
7	BC Initiative	Sabah	2011	SDN BHD	Consultation & Services	2-14	>30	PhD	NGO Experience
8	Boo-Boo	Malang, Valley	2013	SDN BHD & Society	Products from reused/ recycled material	20-30	<30	International Development, Accounting, Engineering, Communications	Fresh graduates
9	Bio Conservancy	Sabah	2011	Sole Proprietorship	Consultation & Advisory Services	2-3	>30	Master	Business / NGO experience
10	Build for Tomorrow	Malang, Valley	2014	SDN BHD	Design Services - Sustainable infrastructure	2-3	>30	Business Development	NGO & Corporate
11	DIBS Coffee	Malang, Valley	2013	SDN BHD	Products & Services	<10	>30	Bachelor	Business consultant
12	Heart Treasures	Samudak	2012	SDN BHD	Handicraft Products & Services	3-5	>30	Accounting	Corporate, Accountant, Craft Artisan
13	Lead4measures	Malang, Valley	2008	SDN BHD & Society	Services (Consultancy) and training on leadership	>60	>30	Accounting, Finance & Economics	Corporate, banking & entrepreneurial
14	Lee Urban Farming	Penang	2013	Sole Proprietorship (Entrepreneur)	Healthy food products and agripreneur modules for urban farming	3-5	>30	IT	IT
15	PACOS	Sabah	1983	Trust	Handicraft/ home made Products & Kindergarten Services	>10	>30	Post-Graduate Degree	Started PACOS as fresh graduates
16	Rapidos	Sabah	2011	SDN BHD	Consultancy Services	>10	>30	Logistic	NGO Experience
17	SAWO	Sabah	1983	Society	Consultation/ advisory services	3 - 4	>30	MA-Gender & Development	Civil Service
18	Tanaka	Samudak	2012	SDN BHD	Traditional Products – Handwoven Songket	>10	>30	PhD in Textile	Corporate banker
19	Tonduana	Sabah	2009	SDN BHD	Products & Services (Rural electrification)	>10	<30	Bachelor Engineering	Fresh graduate
20	Worming UP	Samudak	2013	SDN BHD	Recycling food waste to products -compost, soaps, animal feed & Services	>3	<30	Bachelor Biotechnology	Fresh graduate

Source: Primary data from interviews

4. Findings

Social Enterprises in Malaysia: Typology, Missions, Operating Models

All social enterprises interviewed displayed explicit social and/or environmental aim and are accountable to stakeholders (and not just shareholders), while serving the wider community by creating social, environmental and economic impact (Alter, 2007). Most social enterprises started as a personal initiative, eventually evolving into an organized activity before incorporation. Their aim of incorporating was to enable sustainability, using a business approach to achieve social objectives – part of the dual value creation characteristics towards mission accomplishment (Alter, 2007). While most social enterprises were startups, some were transitioning NGOs. Of the total 20 cases, 8 are based in rural areas, 6 are based in urban areas and 6 based both in urban and rural areas.

Most of the social enterprises interviewed operate hybrid organisations to balance social mission and market sustainability (Alter, 2007). They set clear

social objectives towards social value creation and financial sustainability (economic value creation) targets to achieve the former.

Following Alter's classification model, we mapped the respondent social enterprises' operation as per their mission orientation, operating model and organisation structure. Predominantly (18 out of 20) they are mission-centric where the enterprise activities and social mission are dependent, and the mission is central to the organisation purpose. The social programs are financed directly from the commercial activities. For example, Tonibung's mission of providing electricity to rural interior villages using mini-hydro plants is the core purpose its organisation. Likewise, Biji Biji's core mission is to strive for a sustainable and circular economy by reusing waste materials as well as providing income to underprivileged communities.

Two social enterprise interviewed (BC Initiative and Bio Conservancy) are mission-related (i.e., social mission is related but not necessarily relevant to the organisation's enterprise activity), and another (Rapidea) is mission-unrelated (the social program and enterprise operate independently).

In terms of operating model, we found that 8 are fee for service type, followed by 4 employment model, 3 each based on market linkage model, and mixed model (employment, market linkage and entrepreneurship development) respectively, one each servicesubsidisation and organisation support type. For example, Arus Academy operates on fee for service bases; it organises education camps and workshops to fund after class classes training for students. It also creates packages for Corporate Social Responsibility (CSR) activities on education for disadvantaged students and develops teaching modules for education ministry. Similarly, Leaderonomics runs leadership programmes for corporate, community development and media. Proceeds from these programmes are channeled to the community projects - schools, university campuses, rural communities.

DIBS and Batik Boutique for example operate on employment model. That is, DIBS core mission is to create employment for young people with hearing impairment and Batik Boutique mainly aims to create employment for women from low-income backgrounds. Backyard Tours and 100% Projects operates on market linkage model. Backyard Tours brings eco-tourism to villages by training villagers to be local guides in their own village, to equip them with the skills needed to operate tours. The 100% Project connects individuals and corporations, who are passionate about education, to teachers in need (especially in rural schools) through an online crowdfunding platform or customised partnerships.

In terms of organisation structure, 16 out of 20 social enterprises are based on same entity model, which implies that the social mission is imbedded in its business activity and is structured as the same entity with no parent or host organisation. For example, Tonoti aims to preserve the ancient art of Songket

weaving, by promote and developing new applications and there by improving the lives and livelihoods of women and rural communities. Heart Treasures helps mentally challenged children to engage in creative entrepreneurial activities and Sabah Women's Action-Resources Group (SAWO) is engaged in running community education and awareness programs in schools and other organisations, and counselling and support to those in need within Saba to promote women rights and women empowerment. All these social enterprises are based on same entity type.

Two social enterprises (Rapidea and Bio Conservancy) are based on a structured internally model (i.e., under same entity but social mission is structured separately internally). Another two (PACOS and ANB Agro Trainer) operate on a structured separately model (i.e., social mission is structured as separate entities) respectively. For example, ANB established farms to provide employment to "mothers". It also setup separate entity the Human Capital Development Center (HCDC) to train them to be entrepreneurs, or "mompreneurs" to produce their own cottage industry products. The HCDC now serves as a facility, training and capacity building centre for single and married "mompreneurs" in the B40 group.

Of the 20 social enterprises, 14 are registered as Sendirian Berhad (SDN BHD) -- private limited company, 2 are registered as hybrid of SDN BHD and society, 2 are sole proprietorships, one is a trust and the another is a society (see Table 2).

To recapitulate, in most social enterprises the revenue generating enterprise activities and their social mission are directly linked and dependent. Most of them operate on employment generating, fee for service and market linkage models

N	Social Enterprise	Development Areas	Sector	Rural (R) / Urban (U)	Target Beneficiaries	Mission Orientation	Operational Model	Organisation Structure
1	100% Projects	Education Development	Education	R & U	Public school teachers and students	Mission-Centric	Market Linkage Model	Same Entity
2	ANE Agro Trainee	Socioeconomic	Agriculture	R	Underprivileged women	Mission-Centric	Mixed Model - Entrepreneur Support Model, Employment	Structured as separate entities
3	APE Malaysia	Biodiversity Conservation	Tourism	R & U	Wildlife	Mission-Centric	For-fee Service Model	Same Entity
4	Asia Academy	Education Development	Education	R & U	Public school students	Mission-Centric	For-fee Service Model	Same Entity
5	Backyard Team	Socioeconomic	Tourism	R	Rural communities	Mission-Centric	Market linkage Intermediary Model	Same Entity
6	Batik Boutique	Socioeconomic	Art & Craft	U	Underprivileged women	Mission-Centric	Employment Model	Same Entity
7	BC Initiative	Social Welfare	Corporate	R	Under-served communities	Mission-Related	Service Subsidisation Model	Same Entity
8	Boo-Bop	Environmental Conservation	Art & Craft	U	Society	Mission-Centric	For-fee Service Model	Same Entity
9	Bio Conservancy	Socioeconomic	Tourism / Conservation	R	Rural indigenous communities	Mission-Unrelated	For-fee Service Model	Structured Internally
10	Build for Tomorrow	Urban & Sustainable Living	Infrastructure & Utilities	R & U	Urban and Rural communities	Mission-Centric	Mixed Model - Low-Income Client Market, and For-fee Service Model	Same Entity
11	DIBS Coffee	Socioeconomic	F&B	U	Working impaired	Mission-Centric	Employment Model	Same Entity
12	Heart Treasures	Socioeconomic	Art & Craft	U	Mentally challenged	Mission-Centric	Employment Model	Same Entity
13	Lead4enterprises	Human Capital Development	Corporate	R & U	Society	Mission-Centric	For-fee Service Model	Same Entity
14	Leo Urban Farming	Urban & Sustainable Living	Agriculture	U	Urban communities	Mission-Centric	For-fee Service Model	Same Entity
15	PACOS	Socioeconomic	Agriculture, Cottage	R	Under-served communities	Mission-Centric	Mixed Model	Structured as separate entities
16	Requies	Social Welfare	Public Relations	R	Under-served communities	Unrelated to Mission	Organisational Support Model	Structured Internally
17	SAWO	Social Welfare	Welfare	R & U	Women and Children	Mission-Centric	For-fee Service Model	Same Entity
18	Tonibung	Socioeconomic	Art & Craft	R	Cultural preservation	Mission-Centric	Employment Model	Same Entity
19	Tonibung	Environmental Conservation	Infrastructure & Utilities	R	Under-served communities in rural areas	Mission-Centric	Low-income client market model	Same Entity
20	WasteWorx	Urban & Sustainable Living	Waste Management	U	Urban communities	Mission-Centric	For-fee Service Model	Same Entity

4.2. Entrepreneurship Ecosystem and Sustainability

4.2.1 Market Types

Social enterprises serve two market types: (i) Target market that provides source of income for sustaining the social business model; (ii) Beneficiaries' market, where social value is generated (Alter 2007). Out of 20 sample social enterprises 11 operate on niche or exclusive market, offering unique product or service (see Table 4). Only 5 are operating in mass or open market competing with for-profit businesses. Batik Boutique and Heart Treasures operate in highly competitive art, craft and souvenir industry, and DIBs operates in a highly competitive food and beverage (F&B) sector. The others operate in beneficiary market which warrants welfare subsidisation (as there is little to no charge for their services). For example, services offered by Sabah Womens' Action-Resource (SAWO) are specialized and targeted at vulnerable people in society. Tonibung and PACOS serve the low-income market and require philanthropic support to offer their services (see Table 4). Target markets include business-to-consumer (B2C), business to business (B2B), and business-to-government (B2G). Social enterprises have opportunities in accessing the business-to-government (B2G) markets by virtue of operating in the social

sector. B2B includes corporate social responsibility (CSR) projects, as all public-listed corporations in Malaysia are required to incorporate sustainability strategies in their corporate mission.

DIBs (café) and Backyard Tours mainly operate only in B2C Market. APE Malaysia (wild life) operates both in B2C and B2G markets. ANB Agro Trainer (ANB), Heart Treasures, and Tonibung operate in both B2B and B2C markets. ANB initially attempted to retail its products through Tesco and Giant stores, but could not afford their shelf cost and eventually decided to use smaller hypermarket chains such as Sam's Grocer in Penang and Mydin. ANB also used online platforms, such as SimplyGiving.com, and the Goodshop to market their products. The National Women Entrepreneur Association of Malaysia also helped promote their products. Heart Treasures employs mentally challenged children to produce handmade crafts; such as souvenirs, wedding and corporate premium gifts. They are marketed mostly through word-of-mouth. However, they also received support from other organisations to market their products such as the state library, Hilton Kuching and two other hotels, and the Japan International Cooperation Agency (JICA). Heart Treasures also works with companies through CSR initiatives. Tonibung's target market is the rural community. They built micro-hydro units to supply electricity to the villages using a prepaid payment system. They also sell turbines and provide consultancy services to resorts or other business entities.

Borneo Conservancy Initiative (BCI) and Build for Tomorrow offer services to B2B and B2G markets. BCI has provided consultancy services to the Environmental Protection Department, Sabah Biodiversity Centre (SABC) and the forestry department. They were also engaged by foreign NGOs and companies. As part of WildAsia, Build for Tomorrow provided consultancy services to Tourism Malaysia on eco-tourism. They also collaborated with international schools, 5-star hotels and resorts, and other businesses. 100% Project, Arus Academy, Batik Boutique, Loo Urban Farming, Leaderonomics, SAWO, Tanoti, and WormingUp operate in B2B, B2C and B2G markets

To recapitulate, most of the sample social enterprises have shown their potential in accessing all three key markets – consumer (B2C), business (B2B) and government (B2G). While some compete in mass markets, most others are able to develop niche markets by differentiating their products by virtue of their social mission, and setting premium pricing.

Table 4: Social Enterprises in Malaysia: Markets																
No.	Social Enterprise	Development Areas	Marketing Channels		Beneficiary Markets		Target Markets									
			Word of mouth	Online Marketing Channel	Single beneficiary Market	Online (Offline)	Target Beneficiaries	MSB/MSME/MSO	Domestic Market	Domestic Large Companies	Domestic SMEs	Domestic Govt/Non-Profit	Foreign Market	Foreign Large Companies	Foreign SMEs	Foreign Govt/Non-Profit
1	100%Projects	Education Development	-	✓	-	R	Public school teachers and students	MSB, MSME, MSO	✓	✓	✓	✓	-	-	-	-
2	ANW Agro Trainer	Socioeconomic	-	✓	-	R	Underprivileged women	MSB, MSME	✓	-	✓	✓	-	-	-	-
3	APR Malaysia	Biodiversity Conservation	-	✓	✓	R/U	Wildlife	MSB, MSME	✓	✓	✓	✓	✓	-	-	✓
4	Arise Academy	Education Development	-	✓	-	R/U	Public school students	MSB, MSME, MSO	✓	✓	-	✓	-	-	-	-
5	Backyard Tours	Socioeconomic	-	✓	-	R	Rural communities	MSB	✓	-	-	-	✓	-	-	-
6	Bank Boutique	Socioeconomic	✓	-	-	U	Underprivileged women	MSB, MSME, MSO	✓	✓	✓	✓	✓	-	✓	-

Table 4: Social Enterprises in Malaysia: Markets																
No.	Social Enterprise	Development Areas	Marketing Channels		Beneficiary Markets			Target Markets								
			Word of mouth	Online Marketing Channel	Single beneficiary Market	Online (Offline)	Target Beneficiaries	MSB/MSME/MSO	Domestic Market	Domestic Large Companies	Domestic SMEs	Domestic Government/Institutions	Foreign Market	Foreign Large Companies	Foreign SMEs	Foreign Government/Institutions
7	BC Initiative	Social Welfare	✓	-	-	R	Under-served communities	MSB, MSME	-	✓	-	✓	-	✓	-	✓
8	Bio-Style	Environmental Conservation	✓	-	-	U	General Society	MSB, MSME	✓	✓	✓	-	-	-	-	-
9	Bio Conservancy	Socioeconomic	-	-	-	R	Environment / Rural community	MSB, MSME	✓	-	✓	-	-	-	-	-
10	Build for Tomorrow	Urban & Sustainable Living	-	✓	✓	U/R	Urban and Rural communities	MSB, MSME	-	✓	✓	✓	-	-	-	-
11	CBSS Coffee	Socioeconomic	✓	✓	-	U	Hearing impaired	MSB	✓	-	-	-	-	-	-	-
12	Heart Treasure	Socioeconomic	✓	✓	-	U	Mentally challenged	MSB, MSME	✓	✓	✓	-	✓	-	-	-

No.	Social Enterprises	Development Areas	Marketing Channels		Beneficiary Markets			Target Markets							
			Word of mouth	Online Marketing	Direct	Foreign	Domestic	Target Beneficiaries	MSMEs	MSMEs	MSMEs	Domestic Large Companies	Domestic MSMEs	Domestic MSMEs	Domestic MSMEs
13	Leaderonomics	Human Capital Development	-	✓	✓	✓	✓	General Society	✓	✓	✓	✓	✓	✓	✓
14	Lee Urban Farming	Urban & Sustainable Living	-	✓	✓	✓	✓	Urban communities	✓	✓	✓	✓	✓	✓	✓
15	PACOS	Socioeconomic	-	-	-	-	-	Under-served communities	✓	✓	✓	✓	✓	✓	✓
16	Rapidea	Social Welfare	-	-	-	-	-	Under-served communities	✓	✓	✓	✓	✓	✓	✓
17	SAWO	Social Welfare	✓	-	-	-	-	Women and Children	✓	✓	✓	✓	✓	✓	✓
18	Tanoti	Socioeconomic	-	-	-	-	-	Cultural preservation	✓	✓	✓	✓	✓	✓	✓

No.	Social Enterprises	Development Areas	Marketing Channels		Beneficiary Markets			Target Markets							
			Word of mouth	Online Marketing	Direct	Foreign	Domestic	Target Beneficiaries	MSMEs	MSMEs	MSMEs	Domestic Large Companies	Domestic MSMEs	Domestic MSMEs	Domestic MSMEs
19	Tanoti	Environmental Conservation	✓	-	-	-	-	Under-served communities in rural areas	✓	✓	✓	✓	✓	✓	✓
20	ShawlingUP	Urban & Sustainable Living	✓	-	-	-	-	Urban communities	✓	✓	✓	✓	✓	✓	✓

4.2.2 Finance

The two main sources of funding for social enterprises are market sources from sales of goods and services; and non-market sources such as subsidies and grants, private donations, non-monetary in-kind contributions such as voluntary work (Alter, 2007). Table 5 shows the sources of financing for the sample social enterprises.

Personal Investment and Contribution

In the early stages of start-up, most founders of social enterprises devoted only part time for running them, as they were working as employees elsewhere. For example, the founders of Leaderonomics, Heart Treasures, Arus, Batik Boutique and Tanoti, were working as employees during the initial start-up stages and subsequently left their jobs and started devoting full time to manage their social enterprises.

For example, Ang Hui Ming (Leaderonomics) observed: "We started way back in 2005. That was before we both left General Electric. I left GE in 2005, and then Roshan came out 1 year later." Ryan Blair (Batik Boutique) did not join his wife

Amy, the co-founder, until they had developed a market and was financially self-sufficient. Heart Treasures founder, Kiew, still works as a tax and account consultant to earn an additional source of revenue. She observed, "First 3 years, it was from my own savings. I earned as a tax and account consultant and that was a source of revenue. From the fourth year onwards, people started to know us better, and then through the Amplify Awards we were accepted for other grant programmes."

Seed Funding

Some social enterprises received seed funding through incubator and accelerator programmes under either MaGIC or MyHarapan. These are: 100% Projects, Arus Academy, ANB Agro Trainer, Heart Treasures, Backyard Tours, Loo Urban Farming and WormingUP.

Private Investment

Only Arus and Batik Boutique received business angel investment. Arus found their angel investor through the Penang Science Cluster (PSC). Batik Boutique also received funds from a private investor. Only 3 social enterprises received investment from a third party. BFT is a subsidiary of WildAsia. Tonibung initially received funds from one of PACOS's social programs. Leaderonomics accepted equity shareholding from the Star media group (for-profit corporation).

Grants

Most respondents received grants from sources such as AirAsia Foundation, British Council, MaGIC (Amplify Award), Cradle (venture capitalist) and corporate sponsorship such as the Alliance Bank Bizmart Challenge and Shell Malaysia. The Amplify Award recipients are ANB, Arus, Batik Boutique, Biji-Biji, Heart Treasures, Tanoti and Tonibung. Backyard and 100% Projects did not receive any grant, as they failed to qualify. Loo Urban Farming was the only social enterprise that received a product development grant (RM150k) from a venture capitalist (Cradle).

In-kind Contribution

Some social enterprises received in-kind contributions. For example, ANB received 3 hectares of land for their farming activities. DIBS operates on a rent-free premise subsidised by Gamuda. WormingUp was able to utilise ½ acre of land donated by one of their founders' family. Tanoti also secured a land, rent-free for 50 years. Backyard's founder received a 4 wheel drive vehicle from his family. Initially, Heart Treasures received some materials (e.g. used soft-drink bottles) free of cost. They now receive special discounts for the scraps collected. According to Kiew (Heart Treasures),

Initially, we had to buy from the restaurant RM1.30 per piece. We went there to collect 4 to 5 times. The restaurant owner asked us what we are doing, after we explained ...

they told us that we no longer required to pay. Also, when we buy scrap materials, we get a special discount.

Donation, Crowdsourcing, Loan

As a registered NGO, SAWO has been able to raise donations to sponsor some of their programmes. Guru (ANB) has tried crowdsourcing to raise funds online for one of its cottage industry projects. He stated, "We are setting up a bakery right now. The cost is about RM40k. We are raising money online". Only Batik Boutique managed to secure a loan from a private fund abroad. Their attempt to obtain a loan locally failed, as the founders are foreign nationals.

	Social Enterprise	Sector	Seed Funding					Grants					Reinvestment	In-kind Contribution	Crowdsourcing	Investment	Loans	Donation
			MaGIC	MyHarapan	Business Angels	Personal, Parents	Others	AirAsia	British Council	MaGIC (Amplify)	Cradle	Others						
1	100%Projects	Education	✓															
2	ANB Agro Trainer,	Agriculture	✓			✓	✓		✓	✓		✓	✓	✓	✓			
3	APE Malaysia	Tourism				✓		✓										
4	Arus Academy	Education	✓		✓				✓	✓								
5	Backyard Tours	Tourism	✓	✓										✓				
6	Batik Boutique	Art & Craft			✓	✓				✓			✓			✓	✓	
7	BC Initiative	Corporate				✓						✓						
8	Biji-Biji	Art & Craft							✓	✓		✓						
9	Bio	Conserv				✓							✓					✓

	Conservancy	ation / Tourism																
10	Build for Tomorrow	Infrastructure & Utilities							✓				✓					
11	DIBS Coffee	F&B				✓							✓					
12	Heart Treasures	Art & Craft	✓			✓				✓								
13	Leadernomics	Corporate				✓						✓				✓		
14	Loo Urban Farming	Agriculture	✓			✓					✓							
15	PACOS	Agriculture										✓						
16	Rapidea	Public Relations				✓												
17	SAWO	Welfare										✓				✓		
18	Tonibung	Infrastructure & Utilities						✓		✓		✓						
19	Tanoti	Art & Craft				✓				✓		✓	✓	✓				
20	WormingUP	Waste Management	✓	✓								✓		✓				

Source: Mapped using Interview data

4.2.3. Human Resource

The sources of human resources for the social enterprises in Malaysia include volunteers and interns, permanent or part time staff, mentors and community participation.

Volunteers & Interns

BCI gets volunteers from the Sabah Environmental Protection Association (SEPA). SAWO, ANB, Batik Boutique, BFT and WormingUP also use volunteers. ANB, Batik Boutique and BFT accepts both foreign and local volunteers. ANB and BFT use Couchsurfing.com and Facebook to recruit volunteers. Batik Boutique accepted foreign volunteers through the VIP Programme (by Impact Hub), while WormingUp gets volunteers from UniMas and UCSi. Other social enterprises accepting volunteers are APE, Tonibung, Biji-Biji, Leaderonomics, PACOS and Heart Treasures. Tonibung use volunteers from Engineers Without Borders, particularly to execute their mini-hydro projects.

DIBS, 100% Percent, Arus, BC Initiative, Rapidea, Tanoti, Backyard Tours and Loo Urban Farming do not take volunteers, as their operational models are not suitable for volunteers. 100% Projects frequently recruits interns from Teach for Malaysia (NGO) for administration, vetting and monitoring. Tanoti accepts textile design students (2nd or 3rd year) from UniMas, and interns from France to assist product designing.

Permanent or Part-time Staff

The gap between permanent staff and volunteers and interns is wide, as some organisations only require permanent staff to perform administrative or essential tasks. For example, ANB only has one paid staff, while Batik Boutique has an assistant on payroll to design their products and DIBS has a hearing supervisor capable of communicating with hearing impaired beneficiaries. Only well-established social enterprises like Leaderonomics and PACOS have more than 10 staffs on payroll, while others use mainly volunteers or interns.

Mentors

The accelerator or incubator programmes enable links between social enterprises and mentors. Heart Treasures, LUF, Arus and Backyard received mentor support. In Heart Treasures, the mentor played general management advisory role. Arus received invaluable advice on business setup, while Backyard learned from mentors about marketing and industry insights. Similarly, LUF used mentors to learn business operation.

Community Participation

Community participation is crucial for APE, BFT, Tonibung, PACOS, ANB and Heart Treasures as it ensures sustainability. For example, by working with parents of beneficiaries, Heart Treasures fosters their participation in supporting their children, as well as transferring knowledge and skills to them.

Tonibung and BFT relies on community participation to build infrastructure and transfer knowledge to them through on-the-job training. BFT employs the Orang Asli as full-time workers, which helps them to build the infrastructure themselves and accumulate skills and know-how to maintain the infrastructure.

4.2.4. Culture

Culture influences entrepreneurial behaviour, attitudes, and overall effectiveness (Ahmad & Hoffman, 2008). Specifically, attitudes towards entrepreneurship, and positive societal norms, have been recognized as key components of entrepreneurial ecosystem (Robinson et al., 1991).

Patience or Acceptance

To many social enterprises, patience is a critical factor in engaging and managing their beneficiaries. For example, DIBS required a higher level of patience managing the hearing impaired youth. Similarly, Heart Treasures requires a high degree of empathy and patience to build rapport with beneficiaries. Kiew (Heart Treasures) observed: "He [beneficiary] could not give any answer for the whole day. On another day, Ms Wong kept repeating, still the same. So we started to quarrel in front of him, but there was no response. We tried to simulate an earthquake like scenario like banging tables and etc., but no response. But a breakthrough happened after 19 months."

Ownership

Most social enterprises emphasis on imparting a sense of ownership to their beneficiaries to encourage them to be responsible and to sustain the social benefits generated. For example, although Arus provides training and materials to teachers, they are encouraged to run their teaching programmes independently. Batik Boutique charges one-month fee for training programmes "to create some buy-in". Backyard considers their beneficiary communities as partners and treats them as independent entities. This encourages their commitment and dedication to the projects' success.

Empowerment

Most social enterprises strive to promote empowerment of beneficiaries. According to Jacqueline (Tanoti): "Everything we do, is for the survival of this craft, and secondly, for the empowerment of women within the communities". Similarly, Guru (ANB) observed: "We want the mothers to have a decent income by working with us... or sometimes they can't work in the farm, they have to go outside to work, so we empower them in any way we can". Backyard train their beneficiaries on tour guiding skills, English lessons, costing and pricing strategies in order to empower them to make independent decisions.

Sharing Knowledge

Sharing knowledge is a vital culture, especially in creating awareness. For example, 100% Projects shares with their beneficiaries (teachers) crowdfunding methods. WormingUp conducts weekend workshops at schools, shopping malls and colleges for creating awareness on food waste. Philip (LUF) pointed out: “many college and school students come to see us. We share our experience with them to do their projects. We hope that through sharing of our knowledge... more and more people will start doing it”.

Collaboration

Most social enterprises stress the importance of collaboration with stakeholders and other social enterprises to use resources efficiently. Ang Hui Ming (Leaderonomics) stated: “Because, everybody is trying their own thing, there is a lot of wasted effort. No point competing in the same thing. If you have the same objectives, then we might as well, come together and see if we can forge partnership”. APE also views collaboration with organisations such as MENGO and Ecolights as important. BFT collaborated with Epic Homes to build homes for the flood victims in Kelantan. Like APE, they view doing projects with multinationals and NGOs as complementary rather than competition.

Innovation

Social entrepreneurship is characterised by innovation (Austin et al. 2006). Some social enterprises such as 100% Projects and LUF are actively promoting innovation. Andrew Yong, (100% Projects) noted: “we also want to push them to think out of the box... It’s something we always kept on prodding them so that they do something more”. Ang Hui Ming, (Leaderonomics) stressed: “The challenges is about being innovative... we are in an industry, some people may say that it is a sunset industry. But, we need to continuously improvise and be innovative”.

Networking

Most respondents recognize that networking enables access to markets and beneficiaries, social programme resources, R&D and trade. Previous links with TFM helped 100% Projects to get easy access to teachers, interns and corporate donors. Similarly, SAWO utilised their network with churches and political groups “to get in touch with people who want to work with us for capacity building”. ANB also worked closely with religious groups to reach out to potential beneficiaries. Tonibung’s operations benefited from collaboration. Adrian, (Tonibung) pointed out:

We are having a long term partnership with an organisation called Green Empowerment based in Portland, Oregon. Since 2001, they have been supporting us in technical aspect, what needs to be developed, and R&D. They helped us to connect with practitioners in Indonesia, Sri Lanka, Nepal, etc. We learned from each other. We learned something new and we localised the design.

LUF gained connection to mentors and venture capital through MaGIC and Arus met an angel investor and mentor through the Penang Science Cluster.

4.2.5. Support

The support for social enterprises in Malaysia include external expertise, creating awareness and promotion, and social media.

External Expertise

BCI has forged a long-term partnership with SEPA on developing farming methods for their beneficiaries. Tonibung benefited from the expertise of Green Empowerment and Engineers Without Borders. ANB depended on the Social Welfare Department and police enforcement to diffuse sometimes conflicts between beneficiaries. Heart Treasures and ANB received advice from UKM and UM professors, on adopting suitable legal structure and operational aspects.

Creating awareness and promotion

Most respondents consider support for creating awareness and promoting social entrepreneurship are the most important. Batik Boutique received support from their friends in a public relations company, who arranged promotion in radio, magazines and newspapers. Similarly, a newspaper article about DIBS caught the attention of Gamuda which offered its canteen space for locating DIBS café. Arus was helped by PSC's newsletter to publicise their programme to reach wider community. Universities also provide platform to create awareness on social entrepreneurship. Guru, ANB, stated: "Last year, I went to UUM to give a talk on social enterprise. Three of our beneficiaries came up the stage and shared their experience in front of 1,500 students."

Use of Social media

Most social enterprises, managed to utilise social media effectively to promote their programmes. The popular online media used are Facebook, Couchsurfers, Tripadvisor and Youtube. For example, ANB and BFT managed to recruit hundreds of volunteers for their programmes through Facebook. ANB offered bed and breakfast to foreign volunteers through couchsurfing, and used Youtube for researching. Backyard is the most dependent on social media. Dawson (Backyard) said: "Initially, we had hopes that offline can help us sell better, so we approached hotels. But only few said yes, but we did not get any customers from them. But now, we mostly get customers through our online platform (tripadvisor)".

4.2.6. Policy Framework

Development of suitable policies is essential to bolster growth of overall entrepreneurship, as they impact on all components within the ecosystem (Ahmad & Hoffman, 2008). Malaysian social enterprises have used various

legal structures including Sendirian Berhad (Sdn. Bhd), ROS (Society), Sole-proprietor, Trading license/enterprise and Trust. In order to access a wider market and to diversify income sources, some social enterprises operate under two different legal entities. They prefer Sdn. Bhd (private limited), as it is well-established and is widely recognized as higher status. Although 'society' (non-profit) is more appropriate legal form for a social enterprise, there are some challenges in adopting it. For example, Felicia (Arus), highlighted certain problems:

We registered ourselves as a society in the beginning. During the first year, we were a society, when it came to do a lot of the transactions, it was quite difficult for a society to do it, like banking. There is no online banking or physical banking. In the end, we decided to form a Sdn. Bhd. Also because we wanted to grow bigger. Sdn Bhd in a way is easier to manage and is well known.

Similar view was expressed by Fareea Ma (APE): "We registered ourselves as a Sdn. Bhd. because we wanted to be fast and efficient and wanted to be able to make decisions at a snap of the finger rather than go through the board of trustees". Others such as WormingUp and Heart Treasures adopted private limited status for its perceived credibility and benefits. Tan Pei Chin (WormingUp) explained: "We registered as a Sdn. Bhd., as it is more trustworthy for an investor".

However, if a social enterprise operates as a private limited company, legally it is prohibited to receive funds from philanthropic sources such as CSR funds. Therefore, some social enterprises like Leaderonomics, Heart Treasures and WormingUp adopted a hybrid ownership structure, i.e. Sdn. Bhd. (private limited company) to generate private income and ROS (a society) to access CSR funds or to work with foundations.

Certain sector specific policies also influenced adoption of legal form by some social enterprises. For example, Dawson (Backyard) observed: "we had to go for Sdn. Bhd, because the tourism law requires anyone associated with tourism industry must be an audited company and incorporated. So, we had no choice." Similarly, ANB chose to register as a private limited company to acquire work from government agencies.

5. Factors Contributing to Sustainability

There are two major factors that contribute towards sustainability of the social enterprises in Malaysia: (i) skills and past experience; (ii) marketing opportunities and external support.

5.1. Skills and Experience

Ahmad & Hoffman (2008) stressed that skilled entrepreneurs are defined by their entrepreneurial capabilities. Most respondents agreed on how invaluable businessmanagement and entrepreneurial skills are to their operations. Out of

20 interviewed, 15 have more than one founder. Of them, 11 have at least one founder who has business qualifications or some past experiences in the corporate or business sector. The respondents with no prior experience in the commercial sector have faced various challenges. Most of them are mainly former NGOs or non-profit entities with no experience of income-generating activities.

For example, Jacqueline Fong (Tanoti) and Andrew Yong (100% Projects) strongly stressed the need for some business or corporate experience as essential to operate and succeed as a social enterprise. Felicia (Arus Academy) highlighted:

For a lot of us, when we started this social enterprise, we started it with a passion, rather than [with] business and entrepreneurial [mind set]. So, for us, the initial challenge has always been how do we get the right business model; to make sure that we are in here for the long run; how to network with people; how to connect with people because we cannot do this alone. So, we have to learn along the way.

Ruben Cortez's (BFT) explained that his prior marketing experience and his skills in financial and cost management in the corporate sector helped BFT to become self-sustainable within 3 years of operation. All four founders of Leaderonomics had prior corporate or entrepreneurial experience. They managed to leverage on their experience in human resources, to effectively identify their core business and target markets. They also displayed problem-solving abilities, and were capable of self-reflection, enabling them to identify their weaknesses and widen social impact through organisational growth and venturing into multiple channels of service delivery.

Ryan (Batik Boutique) attributed their marketing success to the co-founder Amy's prior experience in the tourism industry and their connection with fair-trade resellers in their home country (the United States). However, it was only after Ryan, who has an MBA and was a business consultant, started assisting Amy in financial management, the Batik Boutique was able to expand its operations. Founders of Tonibung and LUF identified technical / engineering skills as one of the critical factors for success.

Another important factor behind sustainability is the role of managerial team with complementary skills. For example, Andrew Yong (100% Projects) pointed out: "I think what really marked us out is just that we have a really good team. There are three of us - a programmer, fundraiser and a teacher. It's a perfect combination. To build a platform like this, this is exactly the combination that is needed." Similar view was expressed by Felicia (Arus).

5.2. *Market Opportunities and External Support*

The market for social enterprises may be theoretically wider than that of for-profit businesses, as they try to fill the gap created by market failure (Austin et

al, 2006). However, market opportunities are created by market conditions. For example, Backyard promotes local and indigenous experience in their tour packages. As they are less appealing to the local tourists, they are forced to target foreign market. Cost-subsidisation also contributed to sustainability in some social enterprises. Examples include sourcing production materials at a discount by Heart Treasures, pro-bono trainers of Leaderonomics, and premise and utility subsidisation for DBIs. PACOS and Tonibung attributed their marketing success to their ability to leverage on their international network of NGOs for research and development. Adrian (Tonibung) stated: “we are having a long term partnership with the Green Empowerment, based in Portland, Oregon. Since 2001, they have been supporting us in technical development and R&D”.

The experiences of most social enterprises show that ability to access market (domestic or foreign) is critical for sustainability and this depends on their ability to leverage their domestic and foreign networks.

6. Major Challenges faced by Social enterprises in Malaysia

The major challenges faced by the social enterprises in Malaysia include marketing, retaining beneficiaries, negative perception and lack of public awareness, lack of access to resources, product development and retaining trained volunteers.

The most critical challenge is marketing products and services. For ANB, “marketing is always a problem”, as they produce a relatively elastic product (chili paste) and they compete in the same market targeted by for-profit businesses. Access to foreign market poses even greater challenge. This is the biggest challenge for Backyard as they lack industry knowledge and support. Tanoti also face similar challenge, as they have to sell expensiveintricate crafts, which face tough competition in the foreign markets.

In the case of Batik Boutique, the main challenge is retaining beneficiaries. Ryan (Batik Boutique) observed: “what happens a lot of times in non-profit programmes here is, people do training, they get the machines and then they leave... and say ‘good luck’”

Another challenge identified by the respondents is the negative perception due to lack of legal recognition of social enterprises in Malaysia. The general perception is that social enterprises produce low quality products. This affects the branding of the products sold by social enterprises. Batik Boutique and Tanoti are very sensitive about the quality of their products. Jacqueline Fong (Tanoti) said:

We don’t sell our pity story. We are not here on a charity case. When we sell, we sell on the quality of the product. And that makes us more credible than... please support our poor people. We don’t want our girls to look like charity cases. We want them to be proud and be custodians of our heritage.

Leaderonomics faced a different kind of challenge, credibility of its social business model. The mainstream market actors are sceptical of their social objectives, as they are very profitable. Social enterprises including ANB and Heart Treasures also experienced certain scepticism among the local communities. Lack of general awareness of their social impact is the main factor behind this. Ryan (Batik Boutique) observed: “there is not much awareness of the benefits of buying from a social enterprise or working with a social enterprise [in Malaysia]”. The lack of awareness is mainly attributed to absence of legal recognition. ANB and WormingUp experienced this while attempting to legally register their entities and by Backyard when it tried to obtain tour operating license and convince hotels to promote their packages.

Availability of resources such finance, R&D and technology is important to entrepreneurs (Ahmad & Hoffman, 2008). However, access to these resources pose many challenges to the social enterprises in Malaysia. The first challenge is how to balance cost and welfare. For the social enterprise with embedded employment models (e.g. DIBs, Batik Boutique, Heart Treasures, Tanoti), wages and welfare of their employees is the primary concern. The employees are their beneficiaries. A balance between the cost of wages and pricing strategy is critical to ensure marketability and organisational sustainability. This is highlighted by Felicia (Arus): “We shall have all these high needs school students and all these village communities. We couldn’t charge them. So, we have to come out with a way to keep ourselves sustainable.” Similarly, not only does DIBs pay fair wages, they bear high overheads because of the cost of boarding and other benefits provided for beneficiaries.

Product development is the major challenge to Heart Treasures. But complex process involved in the production process and evaluation at every stage makes prototype development impractical and unsuitable. Like Heart Treasures, DIBs face challenges in diversifying its products. Almost all respondents faced challenges in assembling human resources to support social programmes. For example, ANB and BFT depend more on volunteers and interns in order to cut cost. SAWO faces a different challenge. As most of its volunteers reside in the city, they are unable to dedicate their time to rural areas in Sabah.

Retaining trained volunteering workforce is also a major challenge. According to Fareea (APE): “I am trying to coordinate these volunteers coming to help with a tiger project, they have to be taught how to understand the tiger’s behaviour... And after teaching you just go... It is too much of a waste of time...”, as considerable resources are needed to train new workforce.

Another problem is the dependency on grants to sustain their operations. For example, LUF is still developing a ready to market product. As they generate little sales revenue, they are dependent on grants to sustain product development. Similarly, WormingUp is currently in pilot stage and is dependent on grants. Although Batik Boutique and Tanoti are able to sustain their operations, they are still dependent on grants.

Table 6 summarizes the factors contributing to sustainability of social enterprises and challenges faced by them

Table 6: Sustainability Factors and Challenges faced by the Social Enterprises in Malaysia			
Determinants	Contributing Factor	Key Factor/Challenges	Sustainability Factors
Skilled People Entrepreneurial Capabilities	Past Experience - Corporate - Entrepreneurial - Business education	Business Acumen <i>Challenges</i> Lack of business acumen <i>Key Factor</i> - Management, - Communications & marketing skills	Combination of Background Social development area and business
Opportunities Market Conditions	Collaboration and Networking - Private corporations - NGOs - Foundations - Government agencies - Social enterprises	Access to Market <i>Challenges</i> - Negative perception - Stigma & skepticism - Lack of recognition and credibility <i>Key Factor</i> - Market conditions (niche markets) - Innovation - Cost-effective strategies - Awareness	Multiple sources of income - Market sources - Grants

Resources	Social Goodwill	Funding, Expertise and Human Resources	Programme Support
Access to finance and R&D and technology	- Leverage on expertise - Research and Development	<i>Challenges</i> - Balancing cost and welfare - Product development <i>Key Factor</i> - Innovative operating model - Cost-subsidization - Community participation - Niche markets	- Volunteers - Philanthropic

Table 7: Social Value Created by Social Enterprises in Malaysia

No	Social Enterprise	Social Value Created
1	100% Projects	Supporting public school teachers and students with teaching and learning materials
2	ANB Agro Trainer	Creating jobs and income for rural under-privileged women
3	APE Malaysia	Eco-Tourism / Wildlife protection
4	Arus Academy	Supporting / Tutoring public school students
5	Backyard Tours	Eco-Tourism/ Creating job and income for rural community
6	Batik Boutique	Creating jobs and income for rural under-privileged women
7	Borneo Conservancy (BCI)	Supporting under-served communities
8	Biji-Biji	Urban environmental conservation/ creating jobs for disadvantaged sections
9	Bio Conservancy	Environment conservation/ supporting rural indigenous communities
10	Build for Tomorrow	Environmental conservation/ creating employment
11	DIBS Coffee	Providing employment for young people with hearing

		impairment
12	Heart Treasures	Training mentally challenged young people
13	Leaderonomics	Developing human capital (supporting young people)
14	Loo Urban Farming	Urban environmental conservation
15	PACOS	Creating jobs for remote rural communities, training nursery teachers, organic farming skills
16	Rapidea	Supporting Under-served communities
17	SAWO	Supporting women (victims of abuse) both in rural and urban areas
18	Tanoti	Cultural heritage preservation/ creating employment for rural women and providing training in weaving
19	Tonibung	Providing electricity to remote rural villages/ creating jobs/ training skilled people
20	Worming UP	Urban environment management/ food waste management

Source: Primary data from interviews

Table 7 shows the social value created by the sample SEs in Malaysia. They appear to make significant contribution towards creating jobs for socially disadvantaged women and enhancing household income which reduces poverty especially among rural and urban poor communities.

7. Conclusions and Recommendations

Using entrepreneurship ecosystem framework and data gathered from 20 social enterprises, this study set out to explore the major characteristics of social enterprises in Malaysia; how do the key domains of entrepreneurship ecosystem (market, finance, human capital, culture, support, policy) shape the social entrepreneurship; the factors contributing to sustainability of social enterprises and the major challenges faced by them.

With respect to major characteristics of social enterprises in Malaysia, the findings show that the number of social enterprises serving both rural and urban communities respectively are well balanced. Over two thirds of the founders of social enterprises started their ventures when they were over 30 years of age. Most of the founders have previous corporate or business experience. Some of them have NGO background. There are few fresh graduates among them. The important finding is that most social enterprises that participated in the study are considered successful, as they are able to sustain themselves. Almost all them are mission- centric, and their target beneficiaries include rural communities, women and children, school children and teachers, mentally challenged and hearing impaired. They operate in diverse sectors including tourism, education, art and craft, public relations, agriculture, rural

development and waste management. The specific sector a social enterprise chooses to operate depends on its social mission; which dictates the nature of services and determine market location and beneficiaries served. Most social enterprises in Malaysia operate as hybrid organisations, which enable them to operate either in niche or mass markets, supporting their developmental needs and sustaining their social value creation.

With respect to the influence of ecosystem domains (market, finance, human resource, culture, support, policy), the findings are as follows:

More than half of the sample social enterprises operate on niche or exclusive market, offering unique product or service. Only 25 per cent are operating in mass or open market competing with for-profit businesses. The social enterprises operate across different economic sectors and industries and some of them managed to access foreign markets. Most of them have shown their potential in accessing all three key markets – consumer (B2C), business (B2B) and government (B2G).

At the early startup stage, personal investment is the main financial source. The other financing sources are seed funding from accelerators or incubators; investment from business angels, grants from competition organised by banks and private foundations, venture capital, non-profit organisations and corporate sponsorship programmes. Most social enterprises have received some grants. No one was able to secure a loan from local financial institution. Non-financial contributions received includes land, vehicle, rent-free premise, discount on raw material. Some social enterprises also receive donations from crowdsourcing. Philanthropic funding is crucial to sustainability of social programmes of rural social enterprises.

Business management and entrepreneurial skills proved to be critical for sustainability of operations. It is evident that ability to access market (domestic or foreign) is critical for sustainability and this depends on their ability to leverage domestic and foreign networks. The sources of human resources for the social enterprises in Malaysia include volunteers and interns, permanent or part time staff, mentors and community participation. Except well-established social enterprises, others employ only a small number of permanent staff and they mainly use volunteers sourced from the beneficiary communities, general public, universities, NGOs, and foreign countries. In some cases, mentors (mainly from accelerator or incubator programmes) have become an important resource to drive the organisational growth, and to overcome skills gap.

With respect to culture, most social enterprises put emphasis on imparting a sense of ownership to their beneficiaries and strive to promote empowerment. Knowledge sharing is a vital culture, especially in creating awareness. Most social enterprises stress the importance of collaboration and support among stakeholders and other social enterprises to share knowledge and to complement their social mission. They recognize that networking plays an

important role by providing support such as access to markets and beneficiaries, social programme resources, R&D and trade.

The support for social enterprises in Malaysia include external expertise, creating awareness and promotion, and social media. Most respondents consider awareness and promotion of social entrepreneurship as the most important support received by them. Most social enterprises, managed to utilise social media effectively to promote their programmes. The popular online media used are Facebook, Couchsurfers, Tripadvisor and Youtube. Support required by social enterprises differ in varying levels according to the target markets they serve (urban or rural), social development area (sector) and state of development.

With respect to policy domain, Malaysian social enterprises have used various legal structures including Sendirian Berhad (Sdn. Bhd), ROS (Society), Sole-proprietor, Trading license/enterprise and Trust. In order to access a wider market and to diversify income sources, some social enterprises operate under two different legal entities (hybrid model). Most social enterprises prefer Sdn. Bhd (private limited) to generate private income, as it is well-established and is widely recognized as higher status. They also register as ROS (a society) to access philanthropic funds or to work with foundations.

The study found business management skills are the most critical factor for sustainability, followed by the ability to access market (domestic or foreign) using domestic and foreign networks. The problems faced in accessing markets are caused by negative public perception, stigma and scepticism due to lack of legal recognition.

The social entrepreneurs with no prior experience in the commercial world faced significant challenges, particularly former NGOs or non-profit entities with no experience of income- generating activities. The rural based social enterprises face scepticism among beneficiary communities, and suffer from lack of physical infrastructure and mobility. The urban social enterprises face lack of credibility and have to bear high cost of operation. While physical interaction is essential to build trust with rural beneficiaries, urban beneficiaries can be effectively engaged through online/ social media. As social entrepreneurship in Malaysia is still in a nascent state, and lacks legal recognition, it suffers from lack of public awareness, and a negative perception.

Recommendations

Based on the findings the study makes following recommendations: (i) Social enterprises should be nurtured and supported by developing a strong ecosystem so as to develop the sector which will contribute significantly to inclusive growth; (ii) Without legal recognition and awareness, social enterprises will face major challenges such as gaining market acceptance and growth, so the current SE rating system (SE.ASAS or SE.AC) should be

simplified and better support provided to the applicants; (iii) As different markets and beneficiaries of social enterprises pose different challenges, social enterprises and intermediaries need to find different solutions and approaches to overcome them; (iv) Policy makers need to focus on the development of intermediaries and policies favouring stakeholder participation in social entrepreneurship across all sectors by providing incentives such as tax exemptions; (v) As social entrepreneurship has the potential for reducing poverty and inequality especially between the rural and urban communities, sustainable development goals and inclusive growth objectives should be embedded in the social entrepreneurship ecosystem framework.

Future research should focus on: (i) level of social entrepreneurship awareness and acceptance in society, and its' influence on social enterprises; (ii) identification of distinct challenges and needs of urban and rural social enterprises, and how intermediaries could support them by coming up with distinct sets solutions; and (iii) differences between the matured and relatively new social enterprises; and (iv) perspectives of former NGOs and startup social entrepreneurs and the influences of their past experiences.

References

- Abu-Saifan, S. (2012). Social entrepreneurship: definition and boundaries. *Technology Innovation Management Review*, 2(2).
- Ahmad, N. and A. Hoffman (2008), "A Framework for Addressing and Measuring Entrepreneurship", OECD Statistics Working Papers, 2008/02, OECD Publishing, Paris.
- Alter, K. (2007). Social enterprise typology. *Virtue Ventures LLC*, 12, 1-124.
- Austin, J., Stevenson, H., & Wei-Skillern, J. (2006). Social and commercial entrepreneurship: same, different, or both?. *Entrepreneurship theory and practice*, 30(1), 1-22.
- Baskaran, A., Tang, M., Thiruchelvam K., Shahabudin, S. M. & S.Y.Chan, T. S. Y. (2019). Social Entrepreneurship and Inclusive Growth: Attributes, Perceptions and Roles of Business Incubators and Intermediaries in Malaysia. *Science, Technology and Society*, 24 (3), 486-506.
- Beugre, C. (2017), *Social Entrepreneurship: Managing The Creation Of Social Value*, New York: Routledge.
- Bielefeld, W. (2009). Issues in social enterprise and social entrepreneurship. *Journal of Public Affairs Education*, 69-86.
- British Council, United Nations ESCAP and Yayasan Hasanah (2018). *The State of Social Enterprise in Malaysia 2018*. Available at: https://www.britishcouncil.org/sites/default/files/the_state_of_social_enterprise_in_malaysia_british_council_low_res.pdf
- Chua, Y. P. (2012). *Mastering research methods*. McGraw-Hill Education.
- Dees, J. G. (1998). Enterprising nonprofits. *Harvard business review*, 76, 54-69.
- Dees, J. G., & Anderson, B. B. (2003). For-profit social ventures. *International Journal of Entrepreneurship Education*, 2(1), 1-26.
- Freeman, R. E. (2001). A stakeholder theory of the modern corporation. *Perspectives in Business Ethics* Sie, 3, 144.
- Harding, R. (2004). Social enterprise: the new economic engine? *Business and Strategy Review* 15 (4), 39-43.
- Haugh, H. (2005). A research agenda for social entrepreneurship. *Social enterprise journal*, 1(1), 1-12.
- Hulme, D. (1990). Can the Grameen Bank be replicated? recent experiments in Malaysia, Malawi and Sri Lanka. *Development Policy Review*, 8(3), 287-300.
- Jiao, H. (2011). A conceptual model for social entrepreneurship directed toward social impact on society. *Social Enterprise Journal*, 7(2), 130-149.
- Kadir, M. A. B. A., & Sarif, S. M. (2016). *Social Entrepreneurship, Social Entrepreneur and Social Enterprise: A Review of Concepts, Definitions and Development in Malaysia*.
- Kelley, D., Singer, S., & Herrington, M. (2016). 2015/16 Global Report. *GEM-Global Entrepreneurship Monitor*.
- Leadbetter, C. (1997). *The rise of social entrepreneurship*. Demos, London.
- MaGIC Social Entrepreneurship Unit (2015). "Malaysian Social Enterprise Blueprint: Unleashing The Power of Social Entrepreneurship" Malaysia Global Innovation and Creativity Centre

- Martin, R.J., Osberg, S. (2007). Social Entrepreneurship: The Case for a Definition, *Stanford Social Innovation Review*, pp. 29–39. Spring.
- Ministry of Entrepreneur Development and Cooperatives (MEDC) (2022). The Malaysia Social Entrepreneurship Blueprint 2030 (SEMy2030). Retrieved from: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.kuskop.gov.my/admin/files/med/image/portal/PDF/SEMy2030/SEMy2030_Booklet_ENG.pdf
- Ministry of Entrepreneur Development (2019). Social enterprise accreditation (SE.A) guideline. Kuala Lumpur: Government of Malaysia.
- Mort, G., Weerawardena, J., Carnegie, K., 2002. Social entrepreneurship: towards conceptualization and measurement. *American Marketing Association Conference Proceedings* 13, 5.
- Muller, S. (2012), "Business Models in Social Entrepreneurship". In: C. K. Volkmann, K. O. Tokarski and K. Ernst (eds.), *Social Entrepreneurship and Social Business*, Fachmedien Wiesbaden: Springer Gabler.
- Nasruddin, E., & Fahada Misaridin, N. A. (2014). Innovation for a social enterprise business model: An analysis of key success factors. *International Journal of Organisational Innovation*, 7, 149-157.
- Othman, N., & Ab Wahid, H. (2014). Social entrepreneurship among participants in the students in free enterprise program. *Education+ Training*, 56(8/9), 852 -869.
- Peredo, A. M., & McLean, M. (2006). Social entrepreneurship: A critical review of the concept. *Journal of world business*, 41(1), 56-65.
- Pilinkienė, V., & Mačiulis, P. (2014). Comparison of different ecosystem analogies: The main economic determinants and levels of impact. *Procedia-social and behavioral sciences*, 156, 365-370.
- Robinson, P. B., Stimpson, D. V., Huefner, J. C., & Hunt, H. K. (1991). An attitude approach to the prediction of entrepreneurship. *Entrepreneurship theory and practice*, 15(4), 13- 31.
- Reis, T. (1999). *Unleashing the New Resources and Entrepreneurship for the Common Good: a Scan, Synthesis and Scenario for Action*. W.K. Kellogg Foundation, Battle Creek, MI.
- Said, H., Ahmad, I., Yusof, M. A. M., & Jusoh, A. (2015). Assessing the Role of Higher Education in Developing Social Entrepreneurship in Malaysia: A Review of Literature. *Mediterranean Journal of Social Sciences*, 6(2), 583.
- Schwab Foundation for Social Entrepreneurs (2011), *Outstanding Social Entrepreneurs* 2011, Geneva. <https://www.yumpu.com/en/document/read/7362562/outstanding-social-entrepreneurs-2011-schwab-foundation-for->
- Waddock, S. A., & Post, J. E. (1995). Catalytic alliances for social problem solving. *Human Relations*, 48(8), 951-973.
- World Bank (2003). Linking poverty reduction and environmental management - policy challenges and opportunities. Retrieved June 29, 2017, from <http://documents.worldbank.org/curated/en/347841468766173173/Linking->

poverty-reduction-and-environmental-management-policy-challenges-and-opportunities

World bank (2016). Worldbank. Retrieved 27 November, 2016, from <http://www.worldbank.org/en/country/malaysia/overview>

Zainon, S., Ahmad, S. A., Atan, R., Wah, Y. B., Bakar, Z. A., & Sarman, S. R. (2014). Legitimacy and sustainability of social enterprise: governance and accountability. *Procedia-Social and Behavioral Sciences*, 145, 152-157.

Household Innovation in South Africa: Treading new ground in entrepreneurship development?

Calory Larr Onyango

University of Johannesburg, South Africa

Abstract

Innovation has been recognised as an important cornerstone of economic development. Studies on innovation have tended to focus on formal and informal innovation from a business point of view. Household innovation has not really been considered as part of informal innovation. It has however started gaining the attention of scholars. Bradonjic et al (2019) observe that the household innovation sector remains a poorly understood phenomenon and has been underestimated by decision makers. Few studies have investigated household innovation in the Global South, especially Africa. This paper thus explores and categorizes the nature and types of household innovation taking place in South African townships, using Orange Farm in Gauteng as a case study. The paper also investigates the linkage between household innovation and entrepreneurship, as an effort to embed the sector into the informal innovation paradigm. The paper uses a qualitative approach and uses a thematic approach to analyse the data. The results indicate that even though household innovation is prevalent in the township, some of the innovators are not aware that they have innovated, making it difficult to establish links between the sector and entrepreneurship. In addition, household innovation in the township emerges from necessity, hedonism, personal need, and in many cases is purely a survivalist strategy. The innovations are freely shared, and their diffusion advances human welfare. The study establishes that though some innovations may lead to the setting up of entrepreneurial enterprises, few actually innovate for setting up businesses.

1. Introduction

The importance of innovation in driving the economy and uplifting living standards has been recognised in the literature (Schumpeter, 1934; Fagerberg et al, 2010; Gault & Zhang, 2010; OECD, 2015). Innovation can be described as the process of using new information or knowledge combinations to produce new or improved products, processes or manufacturing methods. It may also involve new ways of doing things, or entering new markets, and is a crucial factor in the dynamism of economic activities (Fagerberg et al. 2010). Most innovation studies have focused on formal innovation (Gault, 2015; Harhoff and Lakhani, 2016; von Hippel, 2017). A growing body of knowledge is emerging that concentrates on informal innovation, and its importance in uplifting living standards in low-income households (de Jong, 2015; Soni, 2018; Charmes, Gault and Wunsch-Vincent, 2016).

Formal and informal innovation differ in terms of their scope, structure, and purpose. Formal innovation can be viewed as systematic and intentional, conducted in a formal setting mainly for commercialization purposes. It is often characterized by a clear and defined process, which includes research and development, prototyping, testing, and commercialization (Raasch and von Hippel, 2019). In addition, formal innovation is usually driven by specific goals, such as increasing market share, improving operational efficiency, or enhancing customer satisfaction. Formal innovation is often carried out by firms and often requires significant resources, including funding, specialized personnel, and infrastructure.

On the other hand, informal innovation happens outside formal settings, and is in most cases needs driven before commercialization (Cozzens and Stutz, 2014; Links, Hart and Jacobs, 2017). Informal innovation will mostly emerge from individuals working alone or in collaboration with others who share similar interests.

The importance of informal innovation has been recognised by the UNDP, which observes that “Grassroots innovations develop through networks of activists, practitioners and organisations generating novel, bottom-up solutions for sustainable development – solutions that respond to the local situation and communities’ knowledge, interests and values. Grassroots innovators are generating valuable knowledge and experience” (UNDP, 2020:8).

Literature on informal innovation has largely dealt with entrepreneurship in the formal economy, without really emphasising the role household innovation contributes to entrepreneurship (Cozzens and Stutz, 2014; Kumar and Bhaduri, 2014; Links et al. 2014; Avenyo & Kraemer-Mbula, 2021). This is despite household innovation being recognized as an important sector of informal or grassroots innovation. Literature that embeds household innovation as part of

informal innovation is still at its infancy (Von Hippel, 2021; De Jong, et al, 2021: Julian et al, 2021; Brandonjic et al, 2019). Jong et al (2021) define household innovation as the creation of functionally novel goods, services, or other applications by users in their own time and without compensation. Von Hippel (2017) considers innovation in the household sector to be an important component to business innovation. Household innovation differs from commercial innovations in the sense that while businesses develop innovations to be sold or adopted by others for commercial benefits, household innovation on the other hand largely results from non- economic reasons. Household innovation can also consist of modification of existing products. Von Hippel and Cann (2021) opine that Innovations that are known to the world but not known to the innovator or her community, could be considered redeveloped innovations and are part of household innovation. Redeveloping a solution that is novel to the user innovator but has already been developed somewhere else may be of value both to the individual and users who obtains the use of a pre-existing solution. In this way, members of their community who were previously unaware of the solution may adopt it for their own use.

It has been suggested that informal innovation has a positive correlation to entrepreneurship. Julian et al (2021) posit that there is a strong relationship between creativity, innovation and entrepreneurship development. Similarly, Carvalho and Madeira (2021) observe that innovation is the specific tool through which entrepreneurs can exploit an opportunity to establish a business or service. Given that household innovation has been observed to be ongoing at household level, it is essential to establish whether the sector is leading to entrepreneurship.

It is evident that household innovation is taking place all over South Africa, and it is observable in both low income and high-income areas (De Jong et al, 2023). However its nature and extent has not yet been mapped nor understood. Brandonjic et al (2019) contends that household innovation is gaining the attention of scholars and is being facilitated by the internet, online communities and tools. However, the sector remains understudied and has been underestimated by decision makers.

This paper is one of the first attempts to connect these two bodies of literature: informal innovation and household innovation, by exploring household innovation in a developing country and looking at the entrepreneurial possibilities of household innovations.

Studies on household innovation have been carried out in the United Kingdom (von Hippel et al, 2012), in the USA (von Hippel et al, 2011), in Japan (von Hippel, 2011, Canada (de Jong, 2013), Finland (de Jong, 2015), South Korea (Kim, 2015), Sweden (Bengtsson, 2017), Russia (Fursov, et al, 2017), and the United Arab Emirates (von Hippel et al, 2017). Household innovation studies in Africa are lacking. The UNDP commissioned a study on Informal innovation

and Business Development: Evidence from South Africa in 2022. This is the only study in Africa that deals with household innovation, albeit from a business point of view. Due to the recognition of the growing importance of the household innovation sector in local economies, there is need for household innovation studies to be conducted in Africa.

This paper thus explores and categorizes the nature and types of household innovation taking place in South African townships, using Orange Farm in Gauteng as a case study. It also investigates the linkage between household innovation and entrepreneurship. The paper is guided by the following research question:

What is the nature of household innovation in South Africa and how is it connected to entrepreneurship?

2. Review of the literature

The Schumpeterian view of innovation is based on the idea that commercial businesses develop innovations to utilise or sell for profit, and that innovation-related investments only pay if others adopt or buy what has been developed (Baldwin & von Hippel, 2011). However, evidence has emerged that innovation development activity also occurs within the household sector (Gault 2018; 2020). While innovation has been understood from a formal outlook involving research, household innovation is proving to be of significant value in terms personal, social and economic development. This section examines the emergence of household innovation literature and discusses the key attributes of the sector.

2.1 Emergence and nature of household innovation

Innovation at the household level has been ongoing since time immemorial. De Jong et al (2021) however note that advances in technology, especially availability of computing devices, the internet and online communities have accelerated the phenomenon leading to an increased ability of household members to develop products with functional novelty.

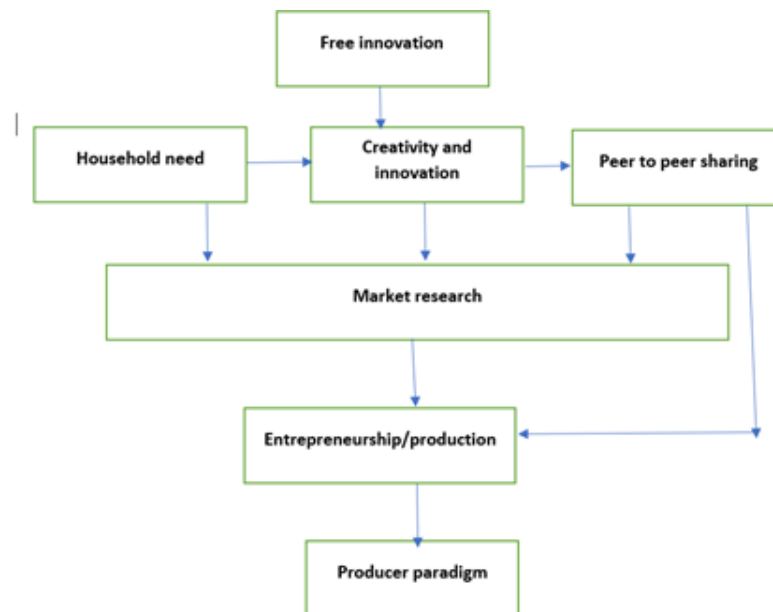
De Jong (2016) emphasizes that innovation by individual end consumers is substantial, and that diffusion of their innovations advances social welfare. However, the author acknowledges that official innovation statistics for the household sector are still missing. Sichel and Von Hippel (2019) attest that international organisations also recently have recognised the potential importance of household innovation and should be considered as part of household capital formation.

Household innovation falls under the free innovation paradigm. Von Hippel (2005; 2017) contends that household innovation may emerge from individuals seeking to satisfy their personal needs. It may also emerge from the benefits

that are to be derived from the innovation process itself such as personal enjoyment, personal learning, or helping others fix specific problems (Raasch and Von Hippel, 2013). The household sector innovation may be developed by individual end consumers solving personal needs (Von Hippel et al, 2011). They may also emerge from in maker or hacker spaces (Mauroner, 2017). Importantly, it has been pointed out that household innovation may emerge from resource deprived citizens developing grassroots innovations, mainly at the bottom of the pyramid (Zechsky et al, 2011).

This paper adopts the free innovation paradigm (von Hippel, 2017) as its theoretical framework. This is illustrated in the figure below:

Fig 1: Household innovation as a possible path to entrepreneurship



Source: adopted from Von Hippel (2017)

Unlike the producer innovation paradigm, which is part of formal innovation, the free innovation paradigm is devoted to types of innovative products and services consumed by households, and not business (von Hippel, 2017). Under this paradigm, consumers in the household sector see a need and spend their unpaid discretionary time developing a product to fulfil this need, or even improving existing ones to be more efficient (von Hippel, 2017). In the paradigm, individuals or groups of innovators who have a potential use for an innovation with a novel function begin the development process without knowing the extent of general demand for the product. In addition, the innovation will mostly be unprotected in terms of patent issues, and will normally be diffused freely through peer to peer to free riders (von Hippel,

2017). Free riders have been described by von Hippel (2017) as are those who benefit from an innovation but do not contribute to developing it. In that sense they get a “free ride.”

2.2 Attributes of household innovation and linkage to entrepreneurship

The importance of household innovation is best captured by van Sichel and Von Hippel (2019), who observe that the rise of free goods and the digital revolution have generated new interest in household activities and how they should be ensured to best capture GDP and social welfare. Van Sichel and von Hippel (2019) call for more focused attention from a national accounting perspective based on household intangible capital. This is due to the amount of time and resources spent by individual households on creating or improving products for their own use. It is evident that household sector innovations are essentially present in essentially all products of interest to consumers (Chen et al, 2020). These range from DIY, craft and shop tools, to services.

Household innovations can be motivated by a range of factors, but arise mostly from personal use (Chen et al, 2020). Von Hippel (2017) however argues that household can emerge due to a range of incentives in addition to personal use. These include the fun or enjoyment that is derived from the innovation development work, learning new skills, helping others, and making money by selling the innovation to commercial interests (von Hippel, 2017).

Certain individual attributes may encourage innovative behaviour among consumers. These include income, technical training and technical work experience. Chen et al (2020) argue that when a consumer encounters an unsatisfied personal need, seeks to learn, wants to help others, make money or simply enjoys the process of innovation, the innovative behaviour will most likely be encouraged if they possess a certain level of education, have some degree of technical competence and have a desire, time and income to facilitate this.

Household innovation is underpinned by the fact that the innovator has to use his own spare time and resources to carry out creative activities. Jong et al (2021) posits that Individual consumers in the household sector increasingly develop products, services and processes, in their discretionary time without payment. Von Hippel (2016) also states that household innovators invest limited time and money to solve problems in their everyday lives – typically a few person-days and a couple of hundred Euros.

Innovation and entrepreneurship have been seen as enablers of economic and social transformation (Isik, Isik and Kiblic, 2016; Jong, 2016; Brem, 2011). Household sector innovations should be considered to be part of the informal economy, which is especially prevalent in developing countries, and can lead to entrepreneurship. This is because the sector is unregulated and is marked by haphazardness and low productivity. Massi, Rondi and Appleton (2022) posit

that the identification of innovation opportunities, coupled with a desire for better incomes, can be a motivating factor leading to the establishment of entrepreneurial activities.

2.3 Formal innovation, informal innovation and household innovation

Literature on formal innovation has tended to focus on products and processes at firm level (Ettie and Rosenthal, 2011; Charms et al, 2015; Foster and Heeks, 2015; Fu, Monhen and Zanello, 2018). Ettie and Rosenthal (2011) examine services versus manufacturing innovation based at the firm level, and their importance in growing the economy. Foster and Heeks (2015) recognise the importance of formal innovation systems but suggest the inclusion of informal innovation as an additional tool which can be used to fight inequalities and social exclusion. Gault (2016) examines the policy relevance of defining and measuring innovation in all sectors of the economy so that they can be included in the System of National accounting.

Literature on informal innovation has on the other hand tended to focus on entrepreneurship in the informal sector (Cozzens and Stutz, 2014; Kumar and Bhaduri, 2014; Avenyo & Kraemer-Mbula, 2021). Cozzens and Stutz (2014) consider informal innovation to be crucial step towards understanding inclusive development. The authors argue for recognition of informal innovation especially those below the radar, bottom of the pyramid and indigenous knowledge. Link et al (2014) argue for a rethinking of traditional notions of innovation, and suggest these narrow views on origin and formality of innovation may obscure reality of the importance of innovation in the economy. Kumar and Bhaduri (2014) note that the growth in innovation literature has often neglected the innovative activities in the informal sector, and call for an appreciation of the 'jugaad' and grassroots role in the economy, together with the socio-economic values generated by these activities. Avenyo and Kraemer-Mbula (2021) on the other hand have focused on informal enterprises and business performance to provide an understanding of how product innovation affects employment in informal enterprises, using Ghana as a case study. Their findings indicate that product innovation has great benefit in the creation of employment in informal enterprises.

It is evident that household innovation has not really been considered as being part of informal innovation. The literature on household innovation has focused more on individual innovators in their personal space (households), especially from rich countries - and has evolved in parallel (and without any connections) to the literature on informal innovation, which has focused on informal businesses and mostly in developing countries (moreover, the literature on informal innovation in developing countries has ignored households). The way "household innovation" is defined, however does overlap with ideas of informality. Despite the conceptual overlaps, the studies of household innovation have not taken off in the context of developing countries and the

connections with the insights from the literature on informal innovation in developing countries have been weak/inexistent.

3. Methodology

This paper is guided by the question:

What is the nature of household innovation in South Africa and how is it connected to entrepreneurship?

To answer this question, a qualitative approach was considered ideal as it would be able to draw upon the lived experiences of the participants. The study utilised observations and interview data that was collected from participants in the study. The in-depth questionnaire focused on the type of innovation, how the innovation was developed, its benefit to others, ownership, community in which the innovation was created and policy. The interviews were done with South Africans living in townships to more deeply understand the nature, process and diffusion of informal innovation, and how this related to any entrepreneurship behaviors. Snowball sampling was used to select the participants. A sample of 11 participants took part in the study, consisting of both men and women, who were in most cases unemployed, or self-employed. Being an exploratory study, the selected sample size facilitated closeness to the respondents, hence enhancing the validity in-depth inquiry in a naturalistic setting.

The collected data was analysed thematically, and is presented below under the broad themes that were identified.

4. Discussion of results

This section present a discussion of results under the broad themes identified as underpinning household innovation. These include a description of the created products, functional novelty, motivation for creation, the innovative process, collaboration, resources used in the innovation, protection of the innovation and linkages to entrepreneurship. An important observation from the data was that household innovation is ongoing in the study area. However, most participants are not aware that the products or services that they have come up with are innovations. It has been suggested that in high income areas, household innovation is mostly done as a hobby, for hedonistic purposes, out of curiosity, or a desire to improve on designs of an existing product (Kim, 2015; De Jong, 2013; von Hippel, 2017). This study has established that household innovation in low-income areas is, however, based on surviving everyday realities of generating income to improve livelihoods in addition to hedonistic motives and curiosity.

4.1 Creation

A wide array of creations were identified from household innovations, which ranged from products (artefacts) to behavioral innovations or services. Some of the innovations identified at the township level are listed in table 1 below:

Table 1: Some innovations emerging in township spaces

Category	Innovation
Products (Artefact) innovation	Chicken plucker, fireless cooking bag, wire weeder, special cooking and warming stand, tire removing tool, stoop and floor polish, rainwater harvester, cross shoulder bag
Services	Groceries stokvel ¹ , savings stokvel, childcare minding,

There is a need to note that some of the innovations may already be on the market, but the innovator has no idea that such a product exists. A few cases of township innovations may fall under this category. A good example is the floor polish developed by one participant. The participant indicated that the low incomes in the area meant that she could not afford the polishes sold in rental outlets. She hence decided to use the molten wax that was left as waste from burning candles and paraffin that she used for cooking. In the township electricity blackouts are a common phenomenon. During such times, the residents will use candles for lighting and paraffin for cooking. The participant hence realized that she had the materials to make the polish and started making it for herself and the selling to people around the township. Later when she realized that the product could sell, the molten wax from her use of candles was not enough, so she identified a factory in town where she could purchase leftover wax at a cheap price.

4.2 Functional novelty

For a product or service to be considered under the household innovation sector, it must have functional novelty (von Hippel et al, 2017; de Jong, 2015; Kim, 2015). Most household innovations in the township exhibit functional novelty. Functional novelty is best illustrated in this study by the fireless cooking bag which saves on energy costs and is convenient in terms of use as it is clean. It serves two purposes. It can be used to finish the cooking process, and can also be used to keep already cooked food warm so that you do not have to use a micro-wave to reheat. The fireless cooker works by continuing to cook food without using any fuel. It is made up of cotton clothing material filled with

a sponge in between the outer and inner cover. It is thick and has a top cover . Depending on size, it is able to accommodate any size of pot. Heat already in the food is employed to keep on cooking. When the food being cooked is halfway done, it is removed and placed in the cooking bag. It is then covered and continues cooking until its done.

Another interesting aspect of functional novelty Is to be found in the wire weeder. The creation is a garden weeder to help remove weeds from among small plants that are still young and fragile, and which can easily break if a hoe or any other implement is used. It is a simple device made from a stiff wire which is twisted and has a handle. It is useful when weeding flowers or vegetables as it does no harm to the flowers. It also does not upturn the soil into clods, but only slightly turns the soil while weeding perfectly. As its inventor stated:

“It is able to accomplish some tasks which hoes, and forks cannot. It weeds close to the plant without touching the plant or even harming the plant. I think that is something new”.

For young crops and plants in the garden, the weeder works better than a hoe or fork. It weeds close to the plant without touching the plant or even harming the plant. It is cheap and uses recycled materials like a wire clothes hangar.

Fig 2: A wire weeder



Source: Self

This indicates that most of the township innovations have an aspect of functional novelty that is entirely new, or is an improvement on an existing device.

4.3 Motivation

At the township level, most participants stated that the motive behind their innovation was not only personal but also survivalist. This included the need to make a living, the need for an extra or alternative income stream, satisfaction in doing a community good, the need to make their informal enterprises more efficient, and savings. For example, in the case of the grocery stokvel, the innovator realized that collaboration would enable her and other people to save money which could later be used to buy groceries in bulk, but was also available for borrowing without security when needed to deal with contingencies. In South Africa stokvels are a society of people who contribute money at regular intervals and from which they can either receive their contributions in lump sum at the end of an agreed period of time, or purchase goods to share, depending on what they agreed the purpose of the stokvel to be. Stokvels are motivated by the need to save in resource constrained communities. Most of the members of the grocery stokvels are low-income earners who depend on piece jobs and grants as a source of income, and may not be in a position to save individually so as to raise enough money to buy groceries in bulk, hence saving money. The creator of the special cooking stand specifically points to the need to save money.

"You can buy gas stoves and even coal stoves in the market. But buying gas to cook and keep the food warm throughout the day will be expensive especially for the kind of food I serve."

Similarly, the rainwater harvester creator was motivated by the need to reduce her water bill and decided that she could use rainwater during the wet season to fill her pool. After coming up with the idea, the creator reports that it took only a few minutes to make her harvester, and did not spend any money as she used recycled material.

There were also hedonic reasons underpinning the innovations. A case in point was the chicken feather plucker, where the creator wanted to do something good for his wife that would make preparing chicken easier. There is a tradition in the township for most black families to have a full meal on Sunday which is popularly referred to as 'Sunday course' and which must have 'seven colors'. Chicken forms part of this course. Some people in the township prefer buying and slaughtering their own chicken. The onus of slaughtering and plucking the feathers is on the buyer. Plucking the feathers is a time-consuming process and involves hard physical work. The chicken plucker works by first scalding the chicken with hot water. Then you swish the chicken inside this feather remover and the feathers fall off on their own, resulting in a clean, featherless chicken ready to cook. In addition to helping his wife prepare the chicken more easily, the creator also stated that his creation would enhance his reputation of being creative and his ability to assist others, as he allows others to borrow his creation for use in their own homes.

4.4 The innovation process

Collaboration

There is evidence of collaboration in coming up with innovations in townships. Collaboration mostly arose as a result of the innovators not having the necessary tools or the know-how to make their creations. For example in the cases of the special purpose cooker and the tire remover, the creators did not have the knowledge nor the tools to do welding. They thus came up with the idea and requested a welder to fabricate their designs. In the special purpose cooker creation, Puleng (not his real name) has crafted a cooker and food warmer. He uses it to cook cow head meat and pap (a type of soft grainy porridge prepared from maize meal, and is eaten by most cultural groups in Southern Africa). The cow head meat is fatty and needs to be consumed hot. The gravy also needs to be drunk while still hot. Puleng states that he made the cooker and warmer to be able to cook the food at cost and also keep it warm throughout the day. Puleng uses firewood to cook the meat and pap. Once done, he uses the embers to keep the food warm by occasionally adding discarded plastic and wood at a low heat. This saves him the cost of buying wood, charcoal, coal or gas.

Fig 3. Special purpose cooker and warmer at a local taxi rank.



Source: self

Puleng came up with the design and used a welder and fabricator to create the cooker, as he has no welding skills. He bought the material and explained to the welder what he wanted made. On collaborating with fabricators, the tire changer stated that:

“The idea was mine but fabricating it I had to pay someone to do it. I explained what it was that I wanted. So we drew up some diagrams and made measurements on different tire sizes then the fabricator made it for me. It was a

professional fabricator who made it for me. I paid him. The idea was mine". For the Child- minding case, the innovator stated that "In the beginning it was just my friend and I. And then we grew the idea by sharing it on the community WhatsApp group which allowed other young mothers who are job seekers to join us. Other moms would join in gradually overtime. What I witnessed with the group is that it really encouraged those who had given up on job hunting to start looking for jobs again as they at least were motivated by seeing others doing so. And our children would be taken care of some of us get called for an interview".

This is a form of collaboration in household innovation in the township.

4.5 Tools needed, time and resources used

Simple tools are used in township innovations. Apart from use of a social platform, all participants reported use of simple tools like scissors, sewing machine, welding tools, pliers, grinder, workbench and a simple stove to melt wax in the case of the stoop and floor polish innovation. The case of Tswelo and her making special bags stand out. Tswelo creates items from used clothes and discarded cloth material to cater to specific needs of customers. The creation of interest in this study was a cross shoulder bag that is used by small scale traders to put their money in. It is convenient as the small-scale traders do not normally have a till to store their cash. This bag is worn around the shoulder and has different components to put in coins and notes. She also makes specialized bags like the one below that can hold your phone when charging.

In terms of money spent on creating the innovation, the amount of money used ranged from a high of R3000 to none. The highest amount of R3000 was spent on the tire remover tool. In spite of this high amount of money spent on the creation, the innovator, who is also an entrepreneur and uses it in his work indicated that:

" For me it is a cost saver as it enables me to remove tires and repair them quickly unlike if I did not have it. Using the old method of a hammer and bars was taking a long time and some people like taxi drivers would avoid bringing me their punctures for repair. With this machine, I am able to do it quickly and the customer does not have to wait for long"

For of the respondents indicated that they spent no money in coming up with their innovations. These were the wire weeder case, the rainwater harvester, the grocery stokvel, the investment stokvel and the rotating childcare case. The last three, being behavioral innovations, involved no initial money being spent. Expenditure only began once the idea had started and was being implemented.

4.7 Protection of the innovation

All the participants in the township innovation cohort reported that they had not protected their innovation in terms of patenting or copyrighting. It is apparent that in townships, household innovation is deemed useful to members of the community and is openly shared. Some participants expressed surprise that anyone can protect something that can be used for a common good. Others were of the opinion that the device created was out there in the open and anyone interested was able to copy it and make use of it. For example Felix, the chicken feather remover creator, did not know what a patent is. After explaining the concept to him, he indicated that he did not protect his innovation but just shared it with friends and people around him. He even asked people close to him if they were interested in one as he was willing to make it for them and charge them a small fee. He shares his invention with others especially neighbours who may want to also use it when they slaughter their chicken. He thus freely reveals his innovation and expressed surprise as to why someone would want to protect something that is useful to others. Interestingly, even those who were using their creations for their entrepreneurial activities do not see any reason as to why they should protect their creations. The tire changing machine creator also held the same views. He stated that:

“All I wanted was to have my machine working. If the fabricator wants to make it for someone else I don’t care. I have my machine. It is working. When it breaks down I will make another one. I do not see the point trademark or confidentiality about this. Look, anyone who comes to my workplace can see how it works and can make it. So why protect it?”

Similarly, the stoop and floor polish creator who sells her product does not see any need to protect it. She indicated that:

“I don't believe in protecting anything especially that has to do with household things. You can share it or just make and sell. I have shared the idea with members of my family. We are all living in the same area, and we help each other. People may not have the time to make it, so I make and sell it to them”.

Puleng, the special purpose cooking devise also stated that:

“I did not protect my creation as it is simple. Even if I wanted to protect it anyone can see its design and copy. It is a simple thing to make so I see no need to protect. Other people have copied it in other areas. I tell them how to make it if they are in the food business that requires a long time cooking so that are able to make it to help themselves”

The lack of protecting one’s creation in the townships could be attributed to cultural beliefs of Ubuntu where one shares any idea or item of value with family and members of a community. It can also be attributed to lack of

knowledge on how to protect an invention, or the perception that the created item is not of great value and may not need to be protected.

4.8 Potential benefits to other people

Most of the innovations created in the township, including the behavioral ones, are of benefit to others in terms of saving money, saving time, convenience and income generation. Starting from the chicken feather plucker, the device is able to reduce the time taken to prepare a single chicken from thirty minutes to less than five minutes. This saves time that can be used for other activities. In addition, neighbours are able to borrow the device and use it in their own homes when preparing chicken. The same case applies to Unathi, the tyre changer creator. He indicated that the innovation enables him to have a quick turn-around time when changing tyres, which saves both him and his customers time and money. Lebo, who came up with idea of a fireless cooking bag, illustrates the concept of altruism very well when she states that:

“here in the township everyone is having issues with the cost of electricity so if they can use it to help themselves why not? It is a very good use of function and the benefit to others is great so we should share it”.

Tswelo, who came up with a cross shoulder bag made from recycled material, also sees her creation as assisting her fellow informal traders keep their money safe and conveniently. She indicated that:

“my business adds value through safety of customer’s money. I also sell my products at a low cost. In addition, I am able to provide items that are specific to the customer needs such as the phone accessory pouches. My products are tailored towards a specific need. it offers value to customer satisfaction because my product is serving its intended purpose to me and my customers”.

Chen et al (2020:3) terms such innovators as ‘Helpers’, who have a strong desire to innovate in order to help others. Raasch & von Hippel(2013) observed that household innovators may sometimes be driven by a desire to help others.

4.9 Diffusion effort

In the township innovation sector, even though there seems to be a lack of effort to diffuse the innovation to other people, the diffusion process takes place through curiosity. This is an aspect of free sharing. Neighbours and other members of the community may see an innovation being utilised and get interested in it. In the case of the chicken plucker, neighbours saw the innovator using the device outside his house and became curious. After explaining and demonstrating to them how the device worked, some became interested, and the innovator was willing to fabricate one for them at a fee.

Interestingly, those who have commercialised their innovations are also willing to share with others. The cross-shoulder bag maker also believes in free sharing even though she sells the items she makes. She stated that:

"I know of people, even friends who are now making the same items and selling which is good as it enables them to have an income. Some people have commercialized my bags and they include friends' family, community members and strangers"

Similarly, the stoop and floor polish maker, who also sells her innovation, stated that people noticed her shiny stoop and were curious about what she was using to do so. She explained the process to them, and they became interested. She only knows of a few people who are making the polish on their own, though not for commercial purposes. In a follow up interview with Mahlomola, the chicken feather remover innovator, he indicated that he did not know how to go about the Commercialisation process. Mahlomola informed me that if he were to know the Commercialisation process and was sure that it would bring him money, he was ready to commercialise it. However, he is still willing to show anyone interested in how to make it.

The diffusion of some of these household innovations advances social welfare. Jong (2016) states that Some household innovations are highly valuable to other consumers. Jong (2016) adds that for social welfare, it is important that these innovations diffuse, or consumers with similar needs would have to independently develop the same innovation. Gambardella et al. (2016) showed that household innovators enhance social welfare by developing innovations which can substitute commercial producers' products. This is the case with the stoop and floor polish, the cross-shoulder bag, the tire changer, the rainwater harvester and the special purpose cooker.

Most creations in the township are adopted by immediate neighbours, friends and other community members. Most of the innovators reported that neighbours and other community members saw the innovation and out of curiosity, inquired about how it worked. Some then became interested in innovation. The wire weeder innovator observed that only one neighbor saw him using it and asked him about it. He is ready to show anyone who is interested in how to make it. He is ready to share freely and attaches no monetary value to it. Similarly, in the case of the groceries stokvel, the creator has made no effort to diffuse the idea but indicates that people see what is happening especially when they are sharing the groceries and are able to decide whether to join or form their own. In the case of the rainwater harvester, the innovator stated that a few members of her family and friends have adopted the innovation and are using it in their own houses. All the township cases indicate a high level of free sharing.

In terms of commercializing the business, only two of the innovators have proceeded to commercialise their creations, while two are using their creations

to improve their businesses. The two who have commercialised their operations are the cross-shoulder bag and stop and floor polish innovators. The reasons behind the Commercialisation is that they are unemployed and needed a steady source of income. Hence when friends and acquaintances inquired about their creation and were willing to purchase, they started making and selling their products. In the case of the two who are using their creations to improve their informal businesses, the special purpose cooker and the tire remover are benefiting from their innovations in terms of efficiency and customer satisfaction. The special purpose cooker enables food to be available to customers while hot, while the tire remover enables fast turnaround time for the customers.

It is not common for household innovations to be adopted by businesses for Commercialisation purposes. Only one innovation from the township was reported to have been adopted by another business, The fireless cooking bag is now available commercially. Lebo, the creator, stated that

".....My daughter told me that she has seen it on the internet. Maybe someone else had the same idea. Me I do it to help others. If someone wants a similar bag and they can buy the materials, I will make for them. If they want to give me something small in appreciation then it is okay. But I would not like to charge people or make it a business..."

It is evident that for this innovator, just like others, does not see the need to commercialise the creation by offering it to businesses. Susan, the rainwater harvester creator also indicated that such a gadget can be bought in a hardware store and modified to harvest the rainwater, hence she sees her creation as having no commercial value as it uses everyday recycled products.

4.10 Enterprenuership

It would then be expected that most household sector innovators, especially in the township, would belong to the informal trading sector as a means of earning their livelihoods. Only three of the township innovators indicated that they are not entrepreneurs. However, on further probing, the wire weeding tool creator affirmed that he moves around in the suburbs seeking piece jobs, which in essence made him an entrepreneur. The two reporting to not being entrepreneurs were the creator of the fireless cooking bag, and the creator of the baby-sitting group, which is a behavioral innovation. The creator of the fireless cooking bag was emphatic that she is not an entrepreneur, and is not interested in becoming one. The innovator of the baby-sitting group is a graduate who is currently unemployed and is seeking formal employment, and is not interested in being an entrepreneur. Mpho, the creator of the investments stokvel, stated that he is not an entrepreneur as yet, but is raising funds to start a business. Apart from the above three, all other township innovators indicated that they are entrepreneurs. From the in-depth interviews, what emerges is that most

participants have to engage in the informal economy as there is scarcity of employment opportunities. As the stoop and floor polish innovator stated:

"....I would say I am an entrepreneur because basically what I do at the end of the day sell things so as to get money to sustain myself and my family. I am unemployed so I make my polish and sell it to earn a living. I also make other things like earrings and bangles which I make from wood and wire. Mine is an informal business but it sustains me. It does not bring in a lot, but it is enough to feed me and my family".

Similarly, the participant who designs and sells personalised bags, stated that:

"Yes I am as I make and sell things. Although it is still an informal business, it is helping me so yes I am an entrepreneur". The special purpose cooker innovator also stated that:

"Yes, I am an entrepreneur. I sell food, I sell cigarettes and snacks here at the taxi ranks you can see from my stock. It is an informal business as I am not registered. I am a one man business and I do everything by myself. I am at this strategic location where many people pass by and buy from me".

The creator of the groceries stokvel, openly stated that her grant was not enough to sustain her, so she has to be an entrepreneur. Her versatility in entrepreneurial activities was voiced by her response that:

"Yes, I am one. I have started so many businesses but some of them have failed after some time. I borrowed money from this stokvel and started selling herbal products. I am still selling them now. I also sell secondhand clothes which I get from town then sell in the location. I try except that sometimes you take money out of the business to use it for other things then the business ends up not doing so well".

The entrepreneur has also been involved in other activities. She states that:

" I have been sewing and making clothes for people. I was even selling meat of chicken feet, mala and heads but my freezer broke down so was not able to continue. I like going out and hustling and not just sitting down at home doing nothing. If I don't do that then my children will starve. So yes. I am an entrepreneur".

The type of entrepreneurial activities in which township creators are involved in range from retailing food and snacks on the street, selling bags, offering gardening services, repairing tyres and doing piece jobs when available. Most of these activities are done out of necessity as a means of survival. The special purpose bag maker reported that she started her entrepreneurial business out of necessity. Due to the economic impact of Covid-19, she was not able to make enough money from her piece jobs, hence started her bags business. The innovator indicated that she is able to make 40 per cent profit from her bag selling business. The tire remover innovator, who uses his innovation in his entrepreneurial business, stated that:

"I am running a successful business of tire repairs and changing. In addition, I repair and polish car rims. My innovation is helping make my business more efficient".

Though not directly related to entrepreneurship per se, the behavioural innovation's value created, especially for the groceries and savings stokvel, lay in the fact that the members are able to benefit from group savings. The groceries members benefit by mobilising their savings to purchase in bulk at the end of a fixed period, while at the same time being able to access their savings to help them at times of contingencies through borrowing from the same. The value created from the child minding creation was availability of time for members to be able to go out and seek economic opportunities. Satisfaction and willingness to assist others were thus benefits that are derived from the entrepreneurial activities of the township innovators.

In terms of value created, the entrepreneurs were not willing to divulge specific amounts of money that they are able to make from their activities. The special purpose cooking stand stated that:

"I get enough money from my business to feed my family. On a typical weekday I am able to sell meat from three to four heads. This gives me a good income. I am using it to even support my daughter who is doing tertiary studies in college, so it is a good source of income".

In terms of non-monetary gains from his entrepreneurial activities, he indicated that:

"I would say I am providing a good service to my customers. They do not have to go home and cook. They can even take the food home as takeaway. So the value I would say I am providing is affordable food at a very low price".

We observe in this case, just like the others, that satisfaction in providing a good service to customers and making profit are added benefits of entrepreneurial activities. The stoop and floor polish creator has been able to employ her nephew from the proceeds of her enterprise. This is an added value.

The need to have a steady income, or an additional income stream, were the main motivating factors behind the entrepreneurial activities of township innovators. Nearly all entrepreneurs in the township sector stated that they needed a means of income to survive, as most of them are unemployed, with some having no other source of income apart from social grants or depending on a spouse. For those whose innovations have led to Entrepreneurship, it was a conscious decision to develop and sell their products as they had identified a need for the product or service and utilised the opportunity to set up the business. In the tire changer innovation case, the creator is an entrepreneur and is using his creation for his business.

He is running a successful business of tire repairs and changing. In addition, he repairs and polishes car rims. His innovation is helping make his business more efficient.

Only three of the township innovators have direct links of their creations with their entrepreneurial activities. These are the tire remover, the cross-shoulder bag innovator and the stoop and floor polish creators. They have used their creation in their informal businesses by either selling their creations to the local community, or using them in their day-to-day operations of their informal business. The tire changer creator indicated that the innovation assists him work faster and more efficiently. The stoop and floor polish creator also indicated that when neighbours became curious about how she was shining her stoop, she saw an opportunity to sell her creation to them, hence her entrepreneurial journey began. In terms of their entrepreneurial activities, most township innovators work alone. Only the stoop and floor polish creator, collaborates with her niece in her business. This can be attributed to the fact that these are simple informal businesses that may not have the capacity to employ or collaborate with others. Some innovation are simple and do not require any collaboration, unless when sharing with others who may want to copy the creation. Susan came up with a rainwater harvesting kit for her house. Susan created a system that collects rainwater from the roof to fill her swimming pool. She used recyclable items (old Kreepy Krawly hose pipes and a 1-liter plastic Coke bottle). Susan cut the back off the Coke bottle and attached it to the end of the downpipe from the roof gutter. She attached a set of old pool cleaning pipes to the front of the Coke bottle and placed the Kreepy hose pipes over the end of the pool so that the water from the roof can run into the pool when it rains. Susan states that she did not work with anyone else. She indicates that this is a basic system that requires only two parts, a plastic cold drink bottle and a pool hosepipes. It does not need collaborating with others.

4.11 Networks, Local communities/informal businesses

Most of the township innovators are embedded in their local communities, who form a source of exchanging ideas, being a ready market and enabling collaboration socially, even if it may not be directly related to household innovation. This is despite the fact that a significant number indicated that they are not related to any community of makers or innovators. The special purpose cooker creator stated that:

"I would say that we are a community of informal traders here at the taxi rank. We are all facing the same problem so if anything affects one it affects us all and we always come together to assist each other. This community is mainly of us informal traders here and the taxi drivers and rank marshals".

In terms of support, one participant reported that:

"We support each other if one has an emergency. Some of us belong to a local burial society. Generally we assist each other depending on how close we are. In addition, we share ideas, news and opinions. We also advise each other on various issues including family matters and business matters".

4.12 Culture, norms and values

Most township innovators could not identify with a specific maker culture, or handicraft culture. Rather they perceive themselves as part of a community that is living in the same area and believe that when anyone comes up with a good idea it is better to share it with others so that they can also benefit. They thus regard the community they are living in as being part of a culture of sharing. The community forms a source of exchanging ideas, being a ready market and enabling collaboration socially, even if it may not be related to household innovation.

Most norms involving household innovation is based on open sharing. Most township innovators freely shares their ideas with others. The special purpose bag creator indicated that:

"I know of people, even friends who are now making the same items and selling which is good as it enables them to have an income. Some people have commercialized my bags and they include friends' family, community members and strangers".

Similarly, the wire weeder creator believes in free sharing. The creator has made no effort to diffuse his innovation. He observes that only one neighbor saw him using it and asked him about it. He is ready to show anyone who is interested in how to make it. He is ready to share freely and attaches no monetary value to it.

It is evident that most household innovators in the township work on their own and are not assisted by any agency or government department. Most participants quoted a lack of finance and mentoring to be the main blocker of creative culture in the township. In addition, lack of skills, government support and lack of knowledge about the innovation process were also mentioned as blockers to township household innovation.

Most innovators depend on small scale businesses or government grants to survive, as nearly all of them do not have formal employment. For example, the special cooker creator is part of a community of informal businesses that operate at the taxi rank. He sees himself as a part of all the people doing business in the taxi rank including the drivers, rank and queue marshals and other informal traders. Similarly, special bag creator interacts with her community through selling items to them. As indicated earlier, she relies on orders from her customers. This gives her a stable base and income from which to operate. She states:

“I feel enabled by this culture because it also adds to my creativity through ideas that are shared yeah, I would say they fit into my culture”.

5.0 Discussion

Creation of products and services that enhance livelihoods is part of household innovation. From this study it is apparent that a range of innovations is taking place in the townships, including products and services. Innovation in the services sector needs to be considered as part of behavioral innovation (von Hippel & Cann, 2020). Since Von Hippel (2017) describes household innovation as the ideation and development of functionally novel products, processes, or other applications by consumers, in their discretionary time without payment, the innovative processes observed in the study area are an important aspect of the sector. Von Hippel and Von Krugh (2016) observe that all innovations consist of a need paired with a responsive solution – a need-solution pair. This holds true for township sector innovations. The need for a product and the ability to create it in an affordable manner drives the innovation process in townships.

The OECD spells out in the 2018 Oslo Manual that “Product innovations must provide significant improvements to one or more characteristics or performance specifications. This includes the addition of new functions, or improvements to existing functions or user utility.” (OECD/Eurostat, 2018: 71). All the innovations at township level exhibited functional novelty. These included efficiency, saving time and money.

Several reasons motivate the creation of products and services at the household level. Jeroen et al., (2021) states that for most household sector innovations, the motive is mainly self-reward. Consumers innovate solutions to problems they experience, satisfy personal needs, or in other ways derive auxiliary benefits from the process of innovation (e.g., fun, helping out others, learning new skills). This study has established that apart from self-reward and personal satisfaction, incomes play an important role in fostering innovation. The low incomes in the townships leads to innovations that will be used to secure or improve incomes, hence the contention that innovation in the townships is survivalist. In addition, the cost of coming up with the innovations is generally low. The tire changer remover, the special cooker, the stokvel innovations are all driven by the need for better incomes.

There is a significant level of collaboration when innovating at the township level. Jong (2016) states that household sector innovators may operate either solo or collaboratively, and found that 10 to 28% of all household innovations were collaborative efforts. In the present study, only four of the eleven participants stated that they had not collaborated with others while creating their innovations. Sichel and Von Hippel (2019) observe that in the U.S., 11 percent of household sector innovations were developed by collaborating

groups of individuals, and 89 percent by individuals working alone. It is evident that levels of collaboration at the township level is significant, and may be comparable to those in the developed countries.

Household innovation is underpinned by the fact that the innovator has to use his own spare time and resources to carry out creative activities. Jong et al (2021) posits that Individual consumers in the household sector increasingly develop products, services and processes, in their discretionary time without payment. Von Hippel (2016) also states that HHS innovators invest limited time and money to solve problems in their everyday lives – typically a few person-days and a couple of hundred of Euros. Due to low incomes in townships, there is minimal expenditure involved in the innovation process, with most innovators opting for recycled materials. In addition, the longest time reported in developing an innovation in the township sector was four months, while the least was reported as minimal with a figure of less than one hour in the case of the wireless weeder. The behavioral innovations of grocery and savings stokvel reported a minimal amount of time used, as they mostly involved discussions. Time is then not an issue for township innovators as most do not have formal employment elsewhere.

Household innovation has only limited impact if innovations do not become available to others. In the absence of dissemination, every citizen facing the same problem has to do a similar effort to solve – a poor use of resources from a societal welfare perspective (von Hippel, 2005; 2017). Free sharing is then the norm in townships. This is because most of the township innovators have no commercial interests, and as such, freely their innovations with other people. None of the people interviewed had tried to protect their innovation with a patent. Even when innovators had commercial intentions, they did not engage in patents or other intellectual property rights. In townships, lack of protection can be partly attributed to cultural beliefs of ubuntu where one shares any idea or item of value with family and members of a community. In addition, there is lack of understanding on how to protect innovations. Also, there is a general belief that the created items are not so valuable that protection would be merited, or simply impossible to protect. In the absence of intellectual property rights, informal innovations are potentially available for anyone to adopt (von Hippel, 2017). The household innovation sector then needs to be considered as part of informal innovation.

When it comes to entrepreneurship, there appears to be a weak link between household innovation and entrepreneurship. Most of the household innovators have not recognised the entrepreneurial potential of their innovations, and tend to share their ideas freely. However, there are some who have used their innovations to drive their informal businesses. The presence of informal entrepreneurs innovating in townships suggests that household innovators may really be more enterprising and entrepreneurial than official statistics indicate (Williams & Nadin, 2010). There is need for policy enactment that can

encourage household innovation to grow into informal and formal businesses that can benefit the innovators themselves.

6.0 Conclusion

There is now ample evidence of the importance of household sector innovation in resource deprived areas, as evidenced in this study. This paper has established the key role of household innovation, thus the need to embed the sector into the informal innovation paradigm. Even though literature on informal innovation has connected the sector to entrepreneurship, however findings from this study show a weak link between household innovation and setting up of enterprises that can exploit the innovations for commercial gain. The connection between household innovation and entrepreneurship is thus still missing. There is need therefore for further research on how household innovation, as part of informal innovation and free innovation, can lead to formal innovation as a producer paradigm. In terms of policy, there should be recognition that despite the widespread adoption of many household innovations in South Africa, the sector needs to be studied more with a focus on types of innovators, digitization and how the fourth industrial revolution can be used to improve the innovation processes. There is also a need for policy actions that will help assist household innovators in resource constrained communities to further exploit their innovations for commercial purposes.

References

- Anderson, J and Billou, N. 2007. Serving the World's Poor: Innovation at the Base of the Economic Pyramid. *Journal of Business Strategy*, volume 28, issue 2, p. 14 - 21
- Armstrong, C., de Beer, J., Kraemer-Mbula, E and Ellis, M. 2018. Institutionalisation and Informal Innovation in South African Maker Communities. *Journal of Peer Production* 14, 2018, Available at SSRN: <https://ssrn.com/abstract=3690364>
- Avenyo, E.K., Tregenna, F. and Kraemer-Mbula, E., 2021. Do productive capabilities affect export performance? Evidence from African firms. *The European Journal of Development Research*, 33, pp.304- 329.
- Baldwin, C. and Von Hippel, E., 2011. Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization science*, 22(6), pp.1399-1417.
- Bengtsson, L. (2017). How Big and Important is Consumer Innovation in Sweden? – A Comparison with Five other Countries, Lund University Working Paper, Lund, 2016.
- Bradonjic, P., Franke, N., Lüthje, C. (2019). Decision-makers' underestimation of user innovation. *Research Policy* Vol 48 (6).
- Carvalho, L C, and Madeira M. 2021. Innovation Management and Entrepreneurship – Introduction. *Administrative Sciences* Vol 11: 73
- Charmes, J., Fred Gault and Sacha Wunsch-Vincent (2016), 'Formulating an Agenda for the Measurement of Innovation in the Informal Economy', in Erika Kraemer-Mbula and Sacha Wunsch-Vincent (eds), *The Informal Economy in Developing Nations: Hidden Engine of Innovation? New economic insights and policies*, Cambridge: Cambridge University Press.
- Chen, J., Su, Y.-S., de Jong, J. P. J., and von Hippel, E. (2020). Household sector innovation in China: impacts of income and motivation. *Res. Policy* Vol. 49, 103–125. doi: 10.1016/j.respol.2020.103931
- Cozzens S and Sutz J. (2014). Innovation in Informal Settings: Reflections and Practices for a Research Agenda. *Innovation and Development*. Vol 4 (1).
- De Jong, J. P. J., (2013). "User Innovation by Canadian Consumers: Analysis of a Sample of 2,021 Respondents," Unpublished Paper Commissioned by Industry Canada, 2013
- De Jong J. (2016). Surveying innovation in samples of individual end consumers. *Eur. J. Innov. Manage.*, Vol. 19 (3) pp. 406-423
- De Jong J., Ben-Menahem SM., Franke N., Füller, J and von Krogh G. (2021). Treading new ground in household sector innovation research: Scope, emergence, business implications, and diffusion. *Research Policy*, Vol 50, (8).
- De Jong J., Mulhuizen M., Cowen D., Kraemer-Mbula E., Onyango L and Von Hippel E. 2023. Informal Innovation and Business Development: Evidence from South Africa. Project Report. UNDP accelerator Labs.
- Ettie J E and Rosenthal S R. 92011). Services vs Manufacturing Innovation. *Journal of Innovation Management*. Vol 128

- Fagerberg, J., Srholec, M. and Verspagen, B., 2010. Innovation and economic development. In *Handbook of the Economics of Innovation* Vol. 2
- Foster, C. & Heeks, R. (2013) Conceptualising inclusive innovation, *European Journal of Development Research*, 25(3), 333-355.
- Foster, C and Heeks, R. (2015). Policies to Support Inclusive Innovation (August 7, 2015). *Development Informatics Working Paper no. 61*, Available at SSRN: <https://ssrn.com/abstract=3433962> or <http://dx.doi.org/10.2139/ssrn.3433962>
- Fu X, Mohnen P, Zanello G. Innovation and productivity in formal and informal firms in Ghana. *Technological Forecasting and Social Change*. 2018 Jun 1;131:315-25.
- Fursov, K., T. Thurner, and A. Nefedova. (2017). "What User-Innovators do that Others Don't: A Study of Daily Practices," *Technological Forecasting & Social Change*, Vol 118 (1)
- Gault, F., 2020. *Measuring innovation everywhere: the challenge of better policy, learning, evaluation and monitoring*. Edward Elgar Publishing.
- Julian, N. O., Hui, H. J., Clement, M., Solomon, E. N., & Elvis, O. K. (2021). The Impact of Creativity and Innovation on Entrepreneurship Development: Evidence from Nigeria. *Open Journal of Business and Management*, 9
- Kim, Y. (2015). "Consumer User Innovation in Korea: An International Comparison and Policy Implications," *Asian Journal of Technology Innovation*, Vol 23(1).
- Kumar, H.; Bhaduri, S. . 2014. Jugaad to grassroot innovations: Understanding the landscape of the informal sector innovations in India. *Afr. J. Sci. Technol. Innov. Dev.*
- Links, A.L.M., Hart, T. and Jacobs, P., 2014. The dynamics of local innovations among formal and informal enterprises: Stories from rural South Africa. *African Journal of Science, Technology, Innovation and Development*, 6(3), pp.175-184.
- OECD/Eurostat. (2019). *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation. The Measurement of Scientific, Technological and Innovation Activities (4th edition)*, OECD/Eurostat/OECD Publishing, Paris/Eurostat, Luxembourg <https://doi.org/10.1787/9789264304604-en>
- Pansera, M & Martinez, F. (2016). Innovation for development and poverty reduction: An integrative literature review. *Journal of Management Development*. Vol 36. 10.1108/JMD-02-2015-0013.
- Raasch, C., and E. von Hippel. (2013). "Innovation Process Benefits: The Journey as Reward." *Sloan Management Review* Vol 55 (1).
- Schumpeter, A.J., 1934. *A Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*, originally published 1911, reprinted in 1934 by Harvard University Press.
- Sichel, D E. and von Hippel, E. (2019). Household Innovation, R&D, and New Measures of Intangible Capital. NBER Working Paper No. w25599, Available at SSRN: <https://ssrn.com/abstract=3346218>
- Soni P. (2017). Innovation and Entrepreneurship in the Informal Economy: Insights from the Ground Zero. In *Book: International Business Strategy* (pp.215-239)

- Von Hippel CD and Cann AB. (2021). Behavioral innovation: Pilot study and new big data analysis approach in household sector user innovation. *Research Policy*, Vol 50 (8). <https://doi.org/10.1016/j.respol.2020.103992>
- Von Hippel E and Krogh G. (2016). Identifying viable “need–solution pairs”: Problem solving without problem formulation. *Org. Sci.*, Vol 27 (1)
- von Hippel, E., S. Ogawa & J.P.J. de Jong (2011), *The age of the consumer-innovator*, MIT Sloan Management Review Vol. 53(1)
- Von Hippel, E., 2006. *Democratizing innovation* (p. 216). the MIT Press.
- von Hippel, E. (2017). *Free Innovation*. MIT Press, Cambridge, MA.
- Von Hippel, E., Jong JPJ and Flowers S. 2012. Comparing Business and Household Sector Innovation in Consumer Products: findings from a Representative Study in the United Kingdom. *Manage Sci.*, Vol 58 (9)
- Von Hippel, E., 2011. Modeling a paradigm shift: from producer innovation to user and open collaborative innovation. *Org. Sci.* Vol 22 (6), 1399–1417.
- Zeschky, M., Widenmayer, B., Gassmann, O., 2011. Frugal innovation in emerging markets. *Res.-Tech. Manage.* Vol 54 (4)
- Gault, Fred (2015), *Measuring innovation in all sectors of the economy*, UNU-MERIT Working Paper 2015- 038, pp. 23.
- Harhoff D and Lakhani K R. (2016) (eds), *Revolutionizing Innovation: Users, Communities and Open Innovation*, Cambridge, MA: The MIT Press.

Notes

¹ Stokvels in South Africa are an invitation only savings or investment groupings to which members contribute a set amount of money regularly, and from which they will receive a lumpsum payment in the form cash or other agreed goods.