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Sustainable business models and grassroots frugal innovations in developing countries

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Abstract

This research explores the origins and evolution of frugal innovations (FIs) within the grassroots communities of developing countries. It scrutinises how these innovations employ inventive business models that hold promise for sustainable development. The analysis centers on distinct aspects of business models, primarily elucidating the concepts of value proposition, value creation, and value capture. FIs, as this study reveals, possess the transformative ability to convert marginalised and underserved populations at the grassroots level into innovative consumer segments. Through an in-depth exploration of three compelling FI (Technology Hub, Albarka Yoghurt and JK Innovation) case studies, this research significantly contributes to the existing literature concerning FI business models. These cases vividly illustrate how individuals constrained by limited access to education, capital, and resources can ingeniously bring affordable products to market, employing unconventional strategies to fulfil the unmet needs of underserved demographics in developing nations."

Keywords: Frugal Innovation; Business Model; Sustainability; Grassroots.

1. Introduction

Frugal innovation (FI) has emerged as an innovative approach to cater to low-income consumers in developing countries [1]. Within business discourse, sustainable business models (SBMs) have recently gained prominence, with FI being recognised as an effective means to serve low-income customers sustainably. The proliferation of FIs is evident, with their presence observed in both developed and developing nations [2,3]. It is worth noting that FI has been defined in multiple ways and shares commonalities with related concepts such as resource-constrained innovation and disruptive innovation [4]. Nevertheless, it can be elucidated as a solution developed under resource constraints and other limitations to create affordable and acceptable products, explicitly catering to customers who cannot afford conventional alternatives [5,6]. India is a focal point for FI, often locally called Jugaad [7,8]. Scholars contend that FIs hold substantial potential for sustainable development due to their inherent incorporation of various sustainability elements driven by necessity [9]. Although sustainable development is characterised by its broad and multifaceted nature, it fundamentally addresses economic, social, and environmental concerns [10]. As the Brundtland report

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articulates, sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Ensuring the availability of cost-effective products and services remains imperative for addressing the requirements of underserved customer segments. However, it is equally crucial to establish sustainable business models to cater to these customer groups [11,12] effectively. A pragmatic approach to sustainable development in developing nations involves crafting a business model centered on frugal innovation [13]. Business models serve as frameworks that elucidate how enterprises propose, generate, and capture value [14,15]. Incorporating sustainability into these business models can extend the scope of value delivery, benefitting customers and society while pursuing ambitious objectives [16]. Notably, FIs deviate substantially from conventional innovations, not only in terms of their products but also in their underlying business models [17]. Existing research underscores their potential as vehicles for advancing sustainable development [9]. Developing countries, characterised by their unique conditions, offer fertile ground for cultivating FI-driven sustainable development initiatives [18]. Remarkably, both major corporations and smaller enterprises are actively engaged in developing FIs. Notable examples include Tata's Nano, GE's MAC 400 ECG machine, Narayana's cardiac surgery solutions, and Aravind Eye Hospitals' cataract surgery innovations [2].

Comprehending the processes by which companies generate and secure value through innovative offerings that extend to remote customer segments holds paramount importance [3]. There needs to be more research examining frugal innovations (FIs) in conjunction with their associated business models within the context of developing nations [19]. Previous investigations have predominantly concentrated on individual FIs and sustainable business models (SBMs). However, a combined examination of these aspects could yield substantial insights into the adequate provision of sustainable services to low-income customers in developing countries. Therefore, the primary objective of this study is to investigate the emergence of FIs in low-income nations, their integration with innovative business models, and their contributions to the overarching goal of sustainable development.

By examining three distinct instances of frugal innovation (FI) implementation within the Nigerian context, this research offers a multifaceted contribution encompassing three pivotal dimensions. This study serves as an insightful platform for identifying and elucidating the challenges encountered by grassroots innovators during the innovation journey. These challenges provide a comprehensive understanding of the obstacles and constraints that individuals at the grassroots level confront when embarking on innovative endeavours.

Furthermore, the investigation explores the intricate dynamics of FIs accompanied by innovative business models, highlighting their pivotal role in promoting sustainable development. These innovative models are showcased as effective mechanisms for catering to underserved customer segments by offering them access to affordable products and services. The paper underscores how this symbiotic relationship between FI and innovative business models significantly contributes to addressing the needs of these marginalised customer groups while fostering sustainable development. However, this study extends its purview to elucidate the inspirational role of grassroots-level FIs in developing nations.

2. Literature review

Frugal innovation (FI) predominantly targets economically disadvantaged customers in developing nations. However, this endeavour is subjected to substantial scrutiny and pressure from diverse stakeholders who advocate for a sustainable approach to serving this demographic. Consequently, there is a growing trend among businesses to cultivate sustainable business models actively. In this discussion, we aim to provide an overview of the existing literature concerning frugal innovation and its intersection with sustainable business development within the specific context of developing countries. Our exploration unfolds as follows:

2.1. FIs and developing nations

The robust economic expansion witnessed in developing nations has spurred a substantial scholarly interest in managing innovation practices within these regions [20,21]. Remarkably, while developed countries have grappled with economic stagnation, developing countries have sustained their economic growth momentum [22]. Additionally, developing countries now represent a significantly more global customer base, drawing heightened attention from corporations. Given these emerging markets' vastness, it is no surprise that an increasing number of enterprises are redirecting their strategic focus toward developing countries. However, it is crucial to recognise that a substantial portion of these customers within developing nations seek affordability in the products they purchase. Consequently, it is imperative to reimagine how resources can be judiciously employed to establish and maintain sustainable businesses in these regions.

Notably, scholars and practitioners have placed considerable emphasis on crafting products tailored for resource-constrained consumers in developing nations [23,24]. Delivering value to these underserved customers represents a central challenge for businesses operating in such contexts [25]. A significant proportion of individuals in developing countries lack the financial means to access conventional products and services, prompting a growing demand for reasonably priced alternatives that meet their essential needs. Furthermore, many of these potential customers reside in remote, often rural, areas and need access to last-mile services.

2.2. Developing Countries and Innovation

Traditionally, innovations originate in developed countries and are transplanted to their developing counterparts [26]. However, recent decades have witnessed a remarkable surge in innovation taking root within resource-constrained settings, particularly within developing nations [4]. Consumers in developing countries possess notably lower purchasing power and distinct preferences, rendering them a fresh frontier for multinational corporations [27]. Western conglomerates often partner with their subsidiaries in developing nations to craft products tailored to local requirements [28], effectively amalgamating advanced expertise with indigenous knowledge to devise pertinent solutions [29]. Creating product innovations aimed at underserved customers in developing nations is increasingly recognised as an opportunity for opening up new markets. However, it is essential to note that the current body of literature contains limited research about cultivating innovation capabilities to serve these underserved customer segments within developing countries [30].

Slight fluctuations in economic growth can lead to significant disparities in income over extended periods [31], with innovation widely acknowledged as a pivotal driver of economic expansion [32]. Developing nations are now witnessing the emergence of novel forms of innovation that offer substantial value at an affordable cost [33]. Within these developing countries' burgeoning economies, indigenous companies and the local branches of global corporations are steadfastly dedicated to catering to underserved customer segments. While the volume of research on innovation within developing countries is on the rise, our understanding of product development at the grassroots level in these nations still needs to be improved. Products crafted with specific regard to the local context within emerging economies hold local and global relevance. Despite potential challenges such as the scarcity of essential raw materials, skilled labour, supportive institutions, regulatory frameworks, policies, and infrastructure for innovation, grassroots-level innovations persistently emerge. FI stands out as a prominent exemplar of such ingenuity.

2.3. Sustainable Business Models

Sustainable Business Models (SBMs) have recently gained prominence within the expanding realm of business model literature [34-36]. These models adopt a triple-bottom-line perspective, encompassing stakeholders' interests, environmental considerations, and societal impacts [34]. As outlined by Massa et al. [37], business models can be perceived in three ways: as characteristics inherent to actual companies, as cognitive and linguistic frameworks, and as formal conceptual representations illustrating how a business operates. Numerous enterprises need help in achieving their sustainability objectives. Consequently, in addition to fostering innovation in products and services, business model innovation is required in order to incorporate revenue mechanisms that support sustainable solutions [38]. Sustainable business models also confer a competitive advantage by fostering the creation and capture of new value.

However, it is essential to acknowledge that Western business models may not be suitable for FIs in developing countries. In these settings, business models must prioritise affordability to cater to the needs of low-income customers. Indeed, meticulously designed business models are imperative to address the unique requirements of these customer segments [26], particularly given that emerging economies often need more essential institutions, infrastructure, and intellectual property rights [39]. Our understanding of integrating innovation and sustainable development within emerging economies still needs to be improved [40]. Consequently, exploring the dynamics of SBMs within the context of developing nations and their alignment with frugal innovations targeting underserved customers presents a compelling avenue for further research.

2.4. Exploration of Frugal Innovation

In recent years, there has been a notable upsurge in innovative initiatives from developing nations, with many of these categorised as "frugal innovations" [43]. Frugal innovation plays a pivotal role in the broader concept of inclusive innovation [42] and has gained increasing significance in fostering social and political empowerment at the grassroots level [43]. The primary objective of FI is to streamline technological complexity to deliver value to customers in resource-constrained environments [25]. Nigeria stands at the forefront of the frugal innovation phenomenon [5,44], characterised by its departure from conventional innovation in aspects such as novelty, target demographics [45], and

business models [18]. Earlier research efforts have offered preliminary insights into how FIs cater to underserved customer segments in developing countries [6,19,42].

FI exhibits particular promise in resource-scarce settings due to its core emphasis on affordability and quality in product offerings [46]. A central challenge in this context revolves around developing innovative solutions with limited resources [47]. Some enterprises even compete in this domain without the advantages of ample resources, advanced technologies, or substantial market influence. This intriguing phenomenon is approached through a composition-based perspective, highlighting how ordinary firms with constrained resources can yield remarkable outcomes [48]. Consequently, it is paramount to specifically comprehend local phenomena and generate theoretical knowledge that transcends national boundaries [49], recognising the importance of contextual insights and broader theoretical contributions within frugal innovation.

FIs employ contextually adaptive approaches to cater to the needs of low-income customers, often emerging organically at the grassroots level in developing countries [21]. Given the scarcity of readily transferrable knowledge in emerging economies, Western companies occasionally find merit in engaging in localised product development endeavours as a means of addressing the requirements of low-income customers [29]. In tandem with established corporations, numerous grassroots innovators, who frequently possess limited educational and technological backgrounds, conceive innovations through unconventional and creative thinking [8]. Knowledge transfer within this context often occurs informally [50]. These innovators devise sustainable solutions by leveraging local resources and repurposing discarded materials. The FIs originating from the grassroots level in emerging economies possess the potential to exert a profound societal impact by serving underserved customers and championing sustainability [51]. However, like any other form of innovation, an appropriate business model remains imperative for achieving commercial success.

3. Study Methodology

In this study, we employed an abductive approach and a multiple case study method, proving effective in both developing and expanding theories [52]. This approach represents a mode of logical inference that initiates from empirical observations and proceeds to construct a plausible conclusion. It seeks to derive the most likely explanation from the available data, serving as a means of reasoning that deduces the optimal interpretation for a given situation [53]. Concurrently, the case study methodology is suitable for gaining profound insights into relatively unexplored phenomena [54]. Although the multiple case study approach has faced criticism for potentially offering superficial descriptions [52], it remains a widely employed research method, particularly in qualitative studies [55].

3.1. Case Study Selected

The subject of grassroots-level frugal innovation has recently gained attention within the emerging literature [1]. To contribute to developing this nascent field, our study examined three instances of grassroots-level FI. Following extensive desk research, we identified these cases, which exhibited several commonalities in their origins and efforts, making them suitable candidates for exploring the FI phenomenon. All three points are in Nigeria and include the Technology Hub in Kebbi, which specialises in local manufacturing. Additionally, there's Albarka Yoghurt Enterprises in Mafara, primarily in processing and producing milk, and JK Innovation in Nomiye, specialising in producing, Sewing and Knitting locally made sweaters and other related clothes.

3.2. Data collection technique

The data collection process encompassed a multifaceted approach involving interviews, secondary data acquisition, and on-site observations, as utilising multiple data sources is fundamental for achieving triangulation and enhancing research validity [54]. In-depth interviews were conducted with the inventors of the innovative products and managerial personnel representing the three case companies. These interviews were conducted face-to-face within the corporate offices and manufacturing facilities of the companies in Kano and Kaduna. Additionally, we engaged in face-to-face interactions with relevant stakeholders. Eight interviews were conducted as part of this study, employing open-structured questions to encourage interviewees to articulate their insights freely.

The interviews yielded valuable insights into the historical trajectories, current statuses, and prospective plans of the companies under scrutiny. The dialogues were partially recorded and subsequently transcribed, although the complete recording of interviews faced logistical constraints that rendered it impractical. Preceding the interview phase, a comprehensive desk research was undertaken to gather secondary data from diverse sources, including corporate websites, media articles, reports, and video materials. This secondary data acquisition enhanced our comprehension of the cases in question and facilitated the formulation of a structured questionnaire for the subsequent collection of primary data.

During our field visits to the companies, meticulous note-taking was conducted, encompassing detailed records of observations and reflective insights, both immediately following the holidays and upon returning from the field. These field notes were subsequently digitised for ease of analysis. Additionally, visual documentation in the form of photographs was undertaken to capture various aspects, including the factory premises, machinery, tools, and operational processes, enriching the dataset with visual information gathered during the on-site visits.

3.3. Data analysis

We employed abduction logic, as previously elucidated, as the underlying rationale for our research approach. The data analysis process was iterative, involving a continual back-and-forth movement between the existing literature and the empirical data, facilitating a comprehensive exploration of the frugal innovation phenomenon.

The collected data was compiled into a unified PDF file and subsequently uploaded to the Atlas.ti platform, a widely recognised and effective tool for conducting qualitative data analysis. The analysis commenced with preselected codes and open coding techniques to capture diverse facets of the business model construct. This initial phase of coding enabled the identification of overarching themes. Open coding entailed thoroughly reviewing the data file to pinpoint and designate appropriate codes. The coding process is primarily aligned with critical components of a business model, explicitly encompassing elements related to value proposition, value creation, and value capture. As the coding activities advanced, we iteratively combined various codes to synthesise broader categories from the initial set of 31 principles.

3.4. Description of the Case Studies

3.4.1. Technology Hub

Muhammad Mairigibo of Kebbi, Nigeria, hails from a region known for its rich tradition of craftsmanship. Growing up, he faced numerous challenges as he came from a family with limited means. Despite these obstacles, he was determined to make a difference in his community. Initially, he worked various odd jobs, such as farming, selling local snacks, and repairing bicycles, all while facing scepticism and criticism from his community. One day, while working as a bicycle repairman, Muhammad became fascinated by the possibilities of technology. He realised that he could apply modern technological concepts to address local challenges and needs in Kebbi. This sparked a vision within him, and he decided to pursue his dream, even if it meant leaving his current job.

With a small amount of money, Muhammad acquired a piece of land and started building a technology hub in Kebbi. In the early stages of his venture, Muhammad also managed to secure a loan of ₦1,000,000 at a 13% interest rate. After numerous attempts, he successfully developed various locally adapted technology solutions, including solar-powered water pumps for irrigation, affordable off-grid energy solutions, and sustainable agricultural practices tailored to Kebbi's climate. These innovations not only improved the lives of local farmers but also created job opportunities for young people in the region.

Muhammad Mairigibo's technology hub in Kebbi soon became a hub for innovation and inspiration in the region. He received accolades and recognition from local and national organisations for his outstanding achievements in leveraging technology to improve the lives of people in Kebbi and beyond. His story is an inspiring example of how local creativity and innovation can profoundly impact communities facing unique challenges.

3.4.2. Albarka Yoghurt Enterprises

Alhaji Sani Hodu of Mafara, Nigeria, was a dedicated farmer and entrepreneur with a deep-rooted passion for dairy production. Hailing from a small, close-knit community, Alhaji Sani was well aware of the challenges faced by local farmers, including the labour-intensive process of manual milking. He had experienced the difficulties of milking cows by hand, especially when no one was available to assist. Witnessing the toll that manual milking took on both farmers and their livestock, Alhaji Sani was determined to find a solution. Drawing inspiration from his farming background and recognising the need for an efficient and cost-effective milking method, he embarked on a journey of innovation.

Alhaji Sani began experimenting with various materials and mechanisms, driven by a vision of developing a low-cost, mechanical milking machine tailored to the needs of smallholder farmers in Mafara. He understood that the lack of electricity in many rural areas made it essential for the device to operate without relying on power sources. During this time, he collaborated with local experts and engineers, investing four years of relentless effort into perfecting his invention. His dedication and ingenuity resulted in the "Albarka Milker," a functional milking machine capable of milking cows at a speed of up to 2 litres per minute.

The success of the Albarka Milker led Alhaji Sani to expand his product line, introducing electrical and battery-powered milking machines to cater to the diverse needs of farmers in the region. Alhaji Sani Hodu's Albarka Yoghurt Company became a symbol of innovation and progress in Mafara, earning him recognition and accolades at both the local and national levels. His unwavering commitment to enhancing dairy farming practices and the livelihoods of local farmers inspired others, reinforcing the idea that ingenuity and local expertise can bring about transformative change in rural communities.

3.4.3. JK Innovation

John Kessy, a visionary entrepreneur from Nomiye, embarked on a transformative journey to uplift his community through the power of innovation. His story begins with a deep concern for the livelihoods of the local women in Nomiye, where traditional hand-knitting was a common practice. Recognising the need for economic empowerment and broader market access, John decided to take action. Growing up in Nomiye, John witnessed firsthand the challenges the women in his community faced. They relied on traditional hand-knitting techniques to create beautiful, handcrafted textiles. However, limited resources and the absence of modern machinery constrained their production capacity and market reach.

Driven to improve the lives of these skilled artisans, John set out to find a solution. His journey began with a dedication to preserving the rich hand-knitting tradition while incorporating modern technology to expand their opportunities. From humble beginnings, John initially worked as a liaison between the artisans and local markets, helping sell their hand-knitted products. However, he recognised that to make a difference truly, he needed to find a way to increase their production capacity and reach a broader market.

Inspired by the potential of technology, John gradually introduced knitting machines to the artisans. This transition allowed them to create textiles more efficiently while preserving the authentic craftsmanship that made their products unique. The incorporation of devices boosted production and opened doors to new markets, both locally and beyond Nomiye. Today, JK Innovation is a testament to John's commitment to blending tradition with technology.

4. Results and Discussion

As stated earlier, a typical business model consists of three fundamental elements: (i) the value proposition, (ii) the value creation process, and (iii) value capture [54]. The value proposition pertains to the promise made by companies to provide value to their customers, while the primary objective of a business entity is value creation. Lastly, value capture is the mechanism that generates value for a company's shareholders. Value creation acknowledges various types of value and interconnectedness, whereas value capture dictates how value is converted into monetary returns [56]. After conducting data analysis, we have formulated a framework for the components of Sustainable Business Models (SBM) in the context of FI, as illustrated in Figure 1 below.

The three enterprises primarily offer value propositions centered on affordability, innovative products tailored for specific niche markets, local job creation, and a commitment to sustainable development. Furthermore, Technology Hub's products possess an aesthetic appeal that appeals to a broad customer base, eliminating the need for continuous electricity supply for their operation. Similarly, the milking and knitting machines are versatile and can function with or without electricity. All three companies provide cost-effective products that do not rely on electricity, distinguishing them from conventional alternatives. This feature will likely attract individuals who need electricity access or prioritise environmental concerns. It's important to note that many people, particularly in developing nations, lack access to electricity and primary healthcare services. Additionally, even when these services are available, they must still be affordable for a significant portion of the population. As a result, frugal products serve as a practical solution for addressing the essential needs of low-income individuals in developing countries.

All three products, directly or indirectly, contribute to the women's empowerment. For instance, affordable sweaters now provide women and children with accessible, warm clothing, and the low-cost milking machine eliminates the need for women to milk cows manually, consequently improving their overall quality of life. In the case of frugal products, a crucial aspect of their value proposition lies in establishing alternative supply chains that ensure convenient product access for target customers. Sustainability plays a significant role in all three instances. For example, Technology Hub manufactures products using reclaimed or abandoned steel materials. Albarka's machines empower both men and women, and the milking device facilitates hygienic milk production. Meanwhile, JK Innovation saves the local community from the significant expenses associated with acquiring sweaters during the winter season.

4.1. Value capture in frugal innovation

The approach to value capture in these three cases diverges from that of traditional companies. They market their products at a competitive price while maintaining satisfactory quality. These enterprises strongly emphasise cost reduction in areas like raw materials, manufacturing, and sales processes. Managing the supply chain poses a significant challenge for all three businesses because their customer base is dispersed across various geographical regions. Despite successfully lowering production costs, the logistical complexities of delivering products to distant locations hinder their ability to scale up and boost revenue. A primary strategy for enhancing competitiveness involves reducing production costs at the source. This is achieved through the utilisation of locally sourced, recycled, and discarded materials and the employment of affordable local labour. Another cost-saving approach is streamlining product features, emphasising essential functionality and simplicity.

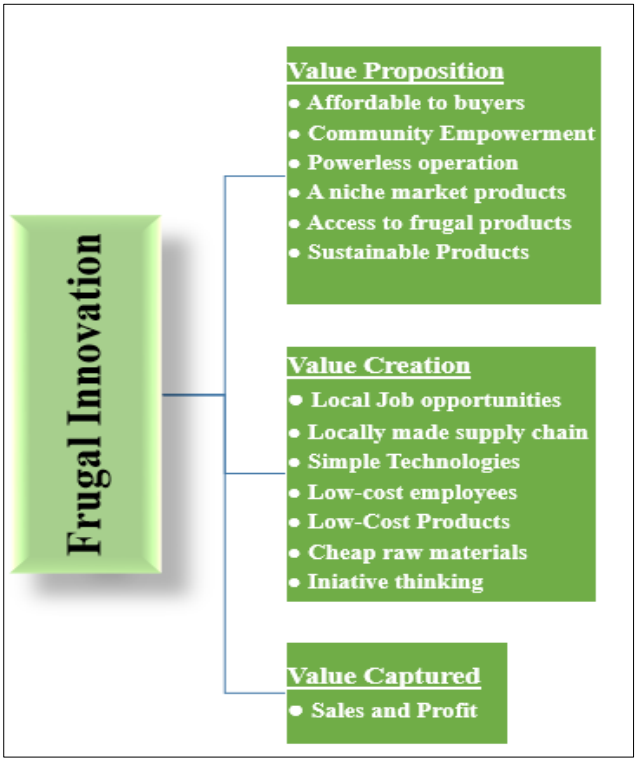

Figure 1 A Framework for Grassroots Frugal Innovations and Sustainable Business Models

Since these enterprises operate at the grassroots level in developing countries, their inherent production costs are naturally low. However, informal and formal support networks play a crucial role in augmenting their value capture, particularly in sales. Local institutional backing extends the reach of these enterprises, enabling them to expand their market presence. Promoting awareness about their frugal products primarily relies on word-of-mouth recommendations and media coverage due to their innovative nature. All three enterprises have received local and national recognition, including media exposure through local news outlets, electronic media, and documentaries.

4.2. Value creation in frugal innovation

All three enterprises have remarkably innovative business models. Despite their limited exposure to advanced sciences and technologies, their ingenuity creates value by utilising cost-effective and straightforward materials, often reusing materials, and employing uncomplicated technologies to generate local employment opportunities. They specialise in producing budget-friendly products, which align well with resource-constrained customers. Leveraging local resources and occasionally recycling materials enables these enterprises to manage their production costs effectively. Their manufacturing processes are uncomplicated and do not rely on sophisticated technologies. Using affordable, locally available raw materials further enables these enterprises to provide economical products to lower-income individuals.

Initially, these enterprises prioritised efficiency by producing more units in less time to deliver value. Subsequently, they enhanced the quality and aesthetics of their products to add further value. Beyond directly employing individuals, these enterprises have played a vital role in preventing potential unemployment, particularly for those who might have had to relocate to urban centres for job opportunities. Notably, they have also generated numerous indirect employment

opportunities. For instance, each machine used in milk production or knitting clothing has created jobs for multiple individuals, including operators and sales representatives.

The inventors crafted their products with limited resources while keeping the target customers and the context of developing countries in mind. Their personal experiences and a deep understanding of the needs of their target customers were pivotal in shaping their products. Proximity to the target market and a profound comprehension of it are vital elements in the context of Frugal Innovation [57]. Furthermore, frugal products typically require minimal maintenance. To establish value and achieve commercial success, all three enterprises faced considerable challenges during the initial years of developing their inventions. One common and critical challenge was identifying the suitable materials or combinations for their products.

Another essential aspect of value creation involves the utilisation of straightforward technologies. Merging material knowledge with innovative ideas empowered all three enterprises to address the challenges low-income customers face in rural areas. The mechanisms in the machines created by these enterprises are user-friendly and uncomplicated, suitable for individuals with varying levels of technical expertise. Traditional firms often overlook these low-income customers. Additionally, the three enterprises reaped benefits from sourcing materials locally and engaging local suppliers in their backward and forward supply chains. Their positive impact further enhanced their standing within their communities.

5. Study Implications

This study illustrates how FIs with innovative business models can address the unmet needs of underserved populations in developing nations, playing a central role in fostering sustainable development. It delves into the development of sustainable business models by grassroots-level enterprises. The analysis focuses on three frugal innovations, primarily viewed through the prism of the three fundamental components of a business model: value proposition, value creation, and value capture. In doing so, this research extends existing business model literature and complements prior investigations related to inclusive development [50], sustainability [9], and the frugal innovation process [42].

The primary value propositions encompass affordability, natural sourcing, electricity-independent operation, niche market targeting, female empowerment, and convenient access to low-cost, sustainable products. These affordable and sustainable offerings are tailored to reach specific niche markets, enhancing underserved customers' well-being while generating local employment opportunities. Moreover, these enterprises provide training to their customers. Frugal innovation creates new niches, including fresh customer bases, novel market segments, and innovative avenues for sustainable development. Crafting creations for developing countries necessitates custom-tailored business models that provide affordable solutions, underlining the importance of grassroots-level knowledge to address local needs.

All three enterprises successfully developed their frugal innovations, often dedicating years to experimentation and product development. This level of commitment is a rarity, as only some individuals would invest such extensive time in creating a product. Therefore, fostering a conducive environment for long-term dedication and technological support at the grassroots level is crucial, particularly in developing countries. Acquiring funding poses another significant challenge for grassroots inventors. Thus, establishing suitable institutions and a supportive financial and technological backing ecosystem becomes imperative. Due to their local roots and limitations in transportation infrastructure, many frugal innovations need help to scale up. Additionally, despite potential patents, these innovations often need more authorised replication, and enterprises cannot take legal action due to weak intellectual property protection in developing countries.

This study carries several implications for practitioners. It illustrates how social issues can be effectively addressed through innovative business models that provide affordable solutions to meet societal needs. Cultivating a frugal mindset, culture, and attitude among scholars, managers, and policymakers is vital for sustainable development. Grassroots-level frugal innovators possess deep insights into low-income customers' challenges in developing countries. In times of dire need, affordable solutions hold significant value propositions for customers who cannot afford existing products. Importantly, frugal innovations at the grassroots level often do not compete with mainstream products; instead, they address overlooked problems that mainstream companies have disregarded. Success in this realm typically follows a protracted struggle, requiring enterprises to overcome obstacles that differ significantly from those Western startups face. Furthermore, frugal innovations can potentially integrate underprivileged individuals into mainstream society, prompting managers to reconsider their assessments of these innovations.

6. Study Limitations and Future Research Works

This study has certain limitations, offering valuable avenues for future research. While it delved into three cases of FI, a more extensive examination of issues could yield more profound insights into the FI phenomenon. Additionally, all three points in this study originate from Nigeria, and broadening the scope to encompass FI in diverse geographical regions could significantly enhance the FI literature's breadth.

FI at the grassroots level for sustainable development is a relatively recent addition to academic discourse. Sustainable business models, FI, and the economies of developing countries are all emerging concepts in academic literature, leaving us with a limited understanding of SBM within this dynamic context. An intriguing area for future exploration is tracing the evolution of FIs from their inception to maturity. Furthermore, investigating how FIs operating at the grassroots level can effectively capture value in developed countries and the associated challenges presents compelling prospects for future research. Business models vary between developed and developing countries and between FIs and mainstream innovations, yet these distinctions have received limited attention in existing literature.

Frugal entrepreneurs' decision-making processes diverge from their counterparts, making it valuable to explore the psychological aspects specific to greedy entrepreneurs. The development of product distribution channels poses significant challenges for FIs, and a thorough examination of related issues could yield valuable insights. Additionally, financial mechanisms supporting FIs remain underdeveloped, making it crucial to explore potential financial tools that can bolster FIs. The development of FIs typically adheres to an effectuation rather than a causation perspective. Effectual entrepreneurs commence their ventures on a small scale and expand by cultivating networks of relationships through iterative cycles. Research studies that delve into safeguarding FIs from unethical replication are also warranted. In summary, as a relatively recent phenomenon, Frugal Innovation presents many opportunities for future research endeavours.

Compliance with ethical standards.

Declaration of conflict of interest

The authors assert that there are no competing interests among any of the parties involved, and they have no intention of exerting any influence on the content of this study.

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