



Frugal innovation and sustainable business models

Mokter Hossain

Center for Entrepreneurship, Qatar University, Doha, Qatar

ARTICLE INFO

Keywords:

Business model
Grassroots innovation
Frugal innovation
Sustainability
Developing countries

ABSTRACT

This study aims to explore how frugal innovations (FIs) emerge at the grassroots level of developing countries and employ novel business models to contribute to sustainable development. It explores various business model elements, mainly viewed through the lens of value proposition, value creation, and value capture. FIs transform underserved customers at the grassroots level into novel consumer groups. By exploring three FI cases, this study contributes to the literature about FI business models. It shows how individuals with limited education, funds, and resources can bring affordable products to market using outside the box thinking to meet the needs of underserved customers in developing countries.

1. Introduction

Frugal innovation (FI) has emerged as a novel way to serve low-income consumers in developing countries [1]. Sustainable business models (SBMs) are an emerging topic in the business discourse, and FI is considered an effective way to serve low-income customers sustainably. Many FIs are emerging in both developed and developing countries [2, 3]. FI has been defined in many ways, and it overlaps with other concepts, such as resource-constraints innovation and disruptive innovation [4]. It can, however, be defined as a resource-scarce solution, developed under resource and other limitations, for producing affordable, acceptable goods to serve customers who cannot afford conventional equivalents [5,6]. India is the epicentre of FI, which is sometimes referred to locally as *Jugaad* [7,8]. Scholars argue that FIs have significant potential for sustainable development, because they incorporate many sustainability elements out of necessity [9]. Although sustainable development is a rather nebulous term, it broadly refers to accommodating various economic, social, and environmental concerns [10]. According to the Brundtland report, “sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Affordable products and services are essential to meet the needs of underserved customers, but developing SBMs is also important to effectively serve these customers [11,12]. A viable approach for succeeding in developing countries is to develop a business model around an FI to achieve sustainable development [13]. Business models describe how firms propose, create, and capture value [14,15], but business models that integrate sustainability can provide value to customers and

the wider society with far-reaching goals [16]. FIs differ significantly from conventional innovations in terms of their products and business models [17], and prior research indicates they show promise for sustainable development [9]. Developing countries are fertile grounds for FI and sustainable development [18], but both large and small firms are developing FIs, such as Tata's Nano, GE's MAC 400 ECG machine, Narayana's heart surgery, and Aravind Eye Hospitals' cataract surgery [2].

Understanding how firms create and capture values with novel propositions that reach customers in remote areas is crucial [3]. Overall, there is a dearth of studies into FIs and their underlying business models in developing countries [19], with them focusing on FI and SBM separately. Nevertheless, studying them together may provide significant insights for understanding how to sustainably serve low-income customers in developing countries. Hence, the objective of this study is to explore how FIs develop in low-income countries with novel business models and contribute to sustainable development.

Using three cases of FI in India, this study makes three main contributions. First, it identifies the challenges that grassroots innovators face in the innovation process. Second, it shows how FIs with novel business models contribute to sustainable development by serving underserved customers with affordable products. Third, it explains how FIs that emerge at the grassroots level can inspire established and other firms to develop products for underserved customers in developing countries.

E-mail address: mokter@qu.edu.qa.

<https://doi.org/10.1016/j.techsoc.2020.101508>

Received 21 July 2020; Received in revised form 2 October 2020; Accepted 23 December 2020

Available online 2 January 2021

0160-791X/© 2020 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

2. Theoretical review

FI mainly serves low-income customers in developing countries, but there is tremendous pressure from various groups to serve them in a sustainable way. Firms are increasingly striving to develop sustainable business models. We discuss here the literature for FI and sustainable business development in the context of developing countries as follows.

2.1. Developing countries

The massive economic growth in developing countries has led to significant scholarly interest in the innovation management practices of these countries [20,21]. Economic growth has continued in developing countries while it has stagnated in developed countries [22]. Developing countries also comprise a larger share of global customers. With their huge markets, it is little wonder that firms are increasingly focused on developing countries. However, many of these customers need affordable products, so it is necessary to rethink how resources can be used effectively to operate a sustainable business in developing countries. Products for resource-poor consumers in developing countries have received significant attention from scholars and practitioners [23,24], and providing value to these underserved customers in developing countries is a key challenge for businesses [25]. Developing countries have a large number of customers who simply cannot afford conventional products and services, so they are increasingly seeking products that are good enough yet affordable. Many of them also live in remote (rural) areas and lack last-mile services.

2.2. Innovation for developing countries

Innovations are typically developed in developed countries and then transferred to developing countries [26]. However, recent decades have witnessed a tremendous growth in innovation within resource-constrained environments, mainly in developing countries [4]. Developing countries' consumers are characterized by significantly lower purchasing power and distinct buying preferences, and they have become a new frontier for multinational companies [27]. Large western firms often collaborate with their subsidiaries in developing countries to develop products to meet local needs [28], thus allowing them to blend advanced knowledge with local knowhow to create appropriate solutions [29]. Product innovations for underserved customers in developing countries have been identified as an opportunity for creating new markets. The current literature features limited research about how innovation capabilities can be developed for these underserved customers in developing countries [30].

Small changes in economic growth can result in large differences in incomes over time [31], and innovation is recognized as a key enabler for economic growth [32]. Developing countries are increasingly seeing new types of innovation that deliver great value at an affordable price [33]. In the emerging economies of developing countries, local firms and the subsidiaries of global firms are constantly endeavouring to serve underserved customers. Even though studies into innovation in developing countries are steadily increasing in number, we still have limited knowledge about product development at the grassroots level of developing countries. Context-specific products that are developed in emerging economies have both local and global significance. Developing countries may lack the raw materials, human resources, supporting institutions, regulation, policy, and infrastructure needed for innovation, but despite these challenges, many innovations are developed at the grassroots level, and FI is an emergent example of this.

2.3. Frugal innovation

Recent years have witnessed a rising number of innovations from developing countries, many of which are called "frugal innovations" [34]. FI plays a significant role in inclusive innovation [35], and it has

become increasingly important for social and political empowerment at the grassroots level [36]. FI aims to reduce technological complexity in order to provide customers value in resource-scarce environments [25]. India is at the forefront of the FI phenomenon [5,37], which differs from conventional innovation in terms of novelty, target market [38], and business model [18]. Prior studies have provided some preliminary insights into how FIs serve underserved customers in developing countries [19,35,6].

FI is especially promising in resource-scarce environments because of its emphasis on affordable, quality products [39]. A key challenge here is to develop novel offerings with limited resources [40], and some enterprises compete without the benefits of resources, core technologies, or market power. This phenomenon is viewed from a composition-based view that emphasizes how ordinary firms with limited resources can generate tremendous results [41]. Hence, specifically understanding local phenomena and generating theoretical knowledge across national boundaries are crucial [42]. FIs embrace context-sensitive approaches to serve low-income customers, and innovations that emerge at the grassroots level of developing countries often serve these customers' needs [21]. Due to the lack of transferable knowledge in emerging economies, Western firms sometimes regard home-based product development as a viable approach for meeting the needs of low-income customers [29]. Along with established firms, many innovators at the grassroots level, often with limited education and technological knowledge, develop innovations using outside-the-box thinking [8], and knowledge transfer at this level may take place informally [43]. These innovators therefore deliver sustainable solutions using local materials and reusing discarded materials. The FIs that originate at the grassroots level in emerging economies can have a significant impact on society, because they serve underserved customers and promote sustainability [44]. Like any other type of innovation, however, an appropriate business model is essential for commercial success.

2.4. Sustainable business models

SBM is an emergent topic in the growing business model literature [45–47]. It integrates a triple bottom-line approach that considers stakeholders, the environment, and society [45]. According to Massa et al. [48], business models comprise three interpretations of their meanings and functions: business models as attributes of real firms, cognitive/linguistic schema, and formal conceptual representations of how a business functions. Many firms struggle to meet their sustainability targets, so along with product and service innovation, business model innovation is needed to integrate revenue mechanisms for sustainable solutions [49]. Sustainable business models also provide a competitive advantage by creating and capturing new value. However, Western business models are unsuitable for FIs in developing countries, where business models need to consider affordability to satisfy low-income customers. Indeed, carefully crafted business models are necessary to serve these customers' needs [26], especially as emerging economies often lack the necessary institutions, infrastructure, and intellectual property rights [50]. The knowledge about how innovation and sustainable development are integrated in emerging economies is limited [51], so understanding SBM in the context of developing countries and FIs for underserved customers presents an interesting research avenue.

3. Method

An abductive approach with a multiple case study method was used in this study, because this is effective for theory development or extension [52]. This approach is a form of logical inference that starts with observations and proceeds to develop a plausible conclusion. It yields the most likely conclusion from the data, so this reasoning infers the best explanation for a situation [53]. A case study, meanwhile, is a suitable method for gaining in-depth insights for underexplored

phenomena [54]. While the multiple case study approach has been criticized for providing mere descriptions [52], it is a widely used research method for qualitative studies [55].

3.1. Case selection

FI at the grassroots level is a subject of emerging literature [1]. To contribute to this emerging field, three cases of FI at the grassroots level were considered in this study. After extensive desk research, we found these cases, which share many aspects in origin and efforts, were appropriate for exploring the FI phenomenon. All three cases are from India, namely Jayashree Industries, MittiCool, and Ksheera Enterprise. Jayashree Industries is based in Tamil Nadu, India. It produces machines for making sanitary pads for women. MittiCool is located in Gujarat state, India and makes various pottery, including a clay refrigerator. Ksheera Enterprise operates from Karnataka, India and makes low-cost milking machines.

3.2. Data collection

Data sources included interviews, secondary data, and observations, because multiple data sources are necessary for triangulation [54]. We interviewed the inventors of the products and the managers of the three case companies, with these interviews taking place face to face in the offices and factories of the companies in Gujarat, Karnataka, and Tamil Nadu. In addition, we conducted several lengthy face-to-face interactions with Prof. Anil Gupta of the Indian Institute of Management, Ahmedabad, India. He provided financial, technical, marketing, and media coverage, as well as other support, to the case companies during their initial stages. We conducted eight interviews altogether in this study. We used open structured questions, so that interviewees could express themselves freely. The interviews provided insights into the companies' past journeys, present statuses, and future plans. We partially recorded the interviews and transcribed the dialogue. We could not fully record interviews for compelling reasons that made this practically impossible.

Before conducting the interviews, we performed desk research to collect secondary data, such as from enterprise websites, media articles, reports, and video clips. This secondary data allowed us to understand the cases better and develop a questionnaire for collecting primary data. During the field visits, we took comprehensive notes and reflected on the field visits, both immediately afterwards and on returning from the field. In addition, we converted these field notes into a digital format. We also took extensive videos and photographs of factory premises, machinery, tools, and operation processes during the field visits, each of which was rather long. For example, the visits to MittiCool and Ksheera Enterprise were a full day each. These long visits enabled us to observe, discuss, and witness different activities to gain a rich knowledge about the cases.

3.3. Data analysis

We applied abduction logic for the reasons indicated earlier. The data analysis comprised an iterative process of going back and forth between the literature and the data, thus allowing us to explore the FI phenomenon. The data was compiled into a single pdf file that was uploaded to the Atlas.ti website, which is widely accepted as an effective tool for qualitative data analysis. We started with preselected codes and open coding to capture different elements of the business model, and this enabled us to find the broad themes. Open coding refers to reading the data file and identifying codes. Our coding was mainly done according to the key elements of a business model—namely value proposition, value creation, and value capture. As we proceeded with the coding work, we did iteration and combination of different codes to develop broad categories of coding from 31 initial codes.

3.4. Case description

MittiCool: Mansukhbhai Prajapati of Gujarat, India came from a family of traditional pottery makers. He had to drop out of school to help support his family by working in different professions, including as a pottery helper, tea seller, and tile manufacturing worker. He experienced backlash from his community, relatives, and acquaintances for doing jobs that did not accord with his status. As a pottery helper, he learned the pottery-making process, while as a tile manufacturing worker, he learned how tile-making machines work. He became intrigued in applying the mechanism of the tile-making machine to making traditional clay pottery. To achieve his dream, he quit his job in the tile factory and borrowed around US\$500 dollars. He bought a piece of land, built his factory there, and bought the necessary machinery. Prof. Anil Gupta provided financial, technical, marketing, and media coverage, as well as other support, to Mansukhbhai Prajapati through the Grassroots Innovations Augmentation Network. At the initial stage, Mansukhbhai Prajapati also managed to borrow US\$10,000 at an 18% interest rate. At the growth stage, he managed to secure a loan from Gujarat state with an interest rate below 1%. He could make 700 earthen pans a day after making numerous attempts to produce quality pans. He sold his pottery items in various villages. The firm now manufactures over 100 types of pottery, including its flagship clay fridge that brought them international fame. The fridge can preserve perishable foods and vegetables through a natural cooling process that requires no power. It is also widely used to store medicines and drugs at a cool temperature in areas where there is no electricity supply. The fridge is therefore especially useful for people who lack access to electricity or cannot afford a traditional fridge. The price of this fridge is around US\$80. Its top chamber stores cold water, while the bottom chamber is used to preserve perishable items. Water drips down from the top chamber through the sidewalls and then evaporates, thus cooling the bottom chamber. An integrated tap in the top chamber allows it to dispense drinking water. Mansukhbhai has been recognized by different local, national, and international organizations for his achievements.

Ksheera Enterprise: Former schoolteacher and farmer Raghava Gowda from Karnataka, India developed a low-cost milking machine. His firm produces the MILKMASTER and IMILKER brands of milking machines. These are especially useful for smallholders who usually have relatively few cows to milk, so they milk them manually. Raghava himself needed to milk his cows manually, but sometimes this was not possible if no one was available who could milk cows. Manual milking can often result in udder infections, as was the case with Raghava's cow.

He also experienced the strain of manual milking, so he became inspired to develop an automated solution. He experimented with different materials and mechanisms and eventually came up with the idea of a low-cost mechanical milking machine based on the concept of the pressure sprayer, especially given the lack of electricity in many rural areas. He took a one-year sabbatical from his school, paying a substitute teacher, so he could focus on his milking-machine project. After four years of development, he successfully created a functional machine that could milk at a speed of up to 2 L per minute, enabling it to milk 10 cows one after another in around an hour. Ksheera Enterprise also now makes electrical and battery-powered milking machines. Raghava has been recognized through state and national awards for his milking machine.

Jayashree Industries: Arunachalam Muruganatham of Tamil Nadu, India developed a simple, low-cost machine for making sanitary pads in order to solve a problem that millions of low-income women across India and other countries face. He was disturbed at learning that several hundred million women in India use unhygienic means, such as ash and dirty cloths, to deal with menstruation. Due to the premature death of his father, Arunachalam had to leave school at an early age. He then worked in a range of jobs, including day labourer, an assistant in a machine-repair workshop, a lathe machine operator, an insurance agent, and a yarn-selling agent. After seeing his newly married wife use a

dirty rag to deal with her menstruation, he bought a pack of sanitary pads for his wife, noting that the price seemed outrageous considering the material used in the product. He therefore started experimenting with different raw materials for making sanitary pads and asked his wife and sisters to test these pads. They were embarrassed and thought him a lunatic, but they reluctantly used them. Next, he approached a group of medical students to test his pads and provide feedback, but they did not cooperate. Eventually, he resorted to walking and cycling while wearing a rubber tube filled with animal blood inside his underwear to re-create the experience of menstruation. His wife and then mother left him for this apparent madness, something that is extremely rare among low-income Indian families. His neighbours also considered him insane and pressured him to leave the community. With a considerable struggle, he managed to recreate the main raw material (wood fibre) that MNCs use in sanitary pads. In 2004, four and a half years after he began, he finished developing a mechanical machine to make sanitary pads, and the rest is history. There are two variants of the machine: a manually operated one costing US\$2000 and a semi-automated model costing US \$3500. He has already installed several thousand machines across India, with each machine providing employment for two or three women. He is called the menstrual man locally, but Time magazine named him in its list of the 100 most influential people in the world in 2014. He has been awarded the Padma Shri by the Indian Government, and even had a full-length movie made in India about his struggle.

4. Analysis and results

As we previously mentioned, a business model typically has three key components: (a) value proposition, (b) value creation, and (c) value capture [56]. Value proposition refers to the value that firms promise to deliver to their customers, while value creation is the main goal of a business entity. Finally, value capture is what delivers value for a firm's shareholders. Value creation recognises different values and their interrelationships, while value capture determines how value is monetized [57]. Based on the data analysis, we developed a framework of SBM components for FI, as depicted in Fig. 1.

Affordable products, new products for a niche market, local employment, and sustainable development are the main value propositions for the three enterprises. Moreover, MittiCool's products are aesthetically appealing to many customers, and its clay fridge has a natural cooling mechanism, so it has no need for electricity. Similarly, the milking machines and machines for making sanitary pads can operate with or without electricity. All three firms offer frugal products that do not require electricity, unlike conventional equivalents, and this will be attractive to many people who either lack access to electricity or care about the environment. The following comment from MittiCool's head of marketing says it all: "Earth products are the best option; we are made of clay and go under the earth after we die." Many people,

especially in developing countries, have no access to electricity or basic healthcare. Many cannot afford such amenities even when they are available, so frugal products offer low-income people in developing countries a means to fulfil their basic needs.

Affordable products are a key proposition of frugal products. Ksheera Enterprise's milking machine is affordable even for farmers with few cows to milk. What is more, several families can share the use and cost of a milking machine, therefore reducing the individual cost even more. Similarly, Jayashree Industries' machines make sanitary pads that are affordable for low-income females. Frugal products can also serve niche markets that are often ignored by mainstream companies. For example, clay fridges, mechanical milking machines, and cheap sanitary pads are aimed at serving customers who are beyond the scope of mainstream firms. While the milking machine is a fresh product, Jayashree Industries fills a niche market in two ways. First, its machines allows women and small NGOs to start a social enterprise and provide employment for women. Second, it provides a means for low-income females to care for menstruation hygienically. These social enterprises often have brand names of their own. Indeed, over a thousand brands of sanitary pads are based on the machines of Jayashree Industries. Low-price products in niche markets have provided these social enterprises with the opportunity to offer promising value propositions to their target customers.

All three products, either directly or indirectly, contribute to female empowerment. For example, women now have access to affordable sanitary products, and many women no longer have to manually milk their cows thanks to the low-cost milking machine, thus uplifting their quality of life. For frugal products, one element of value proposition is reaching target customers with alternative supply chains, so customers can receive their products easily. All three cases have a significant element of sustainability. For example, MittiCool's products are made from clay, Jayashree Industries' machines empower women, and the milking machine helps produce hygienic milk. MittiCool argues that its "products develop green societies in rural areas, thereby contributing to reducing the carbon footprint".

4.1. Value creation

All three enterprises have exceptional business models. Even though the inventors were unfamiliar with advanced sciences and technologies, they created value using low-cost materials, used materials, and simple technologies to generate local and other employment for people making low-cost products. In addition, the lower costs to develop a product suits resource-scarce customers.

The enterprises use local materials and sometimes reuse materials, thereby managing to limit their production costs. For example, MittiCool uses local clay to make its products, while Jayashree Industries encourages its social enterprises to use local materials such as banana

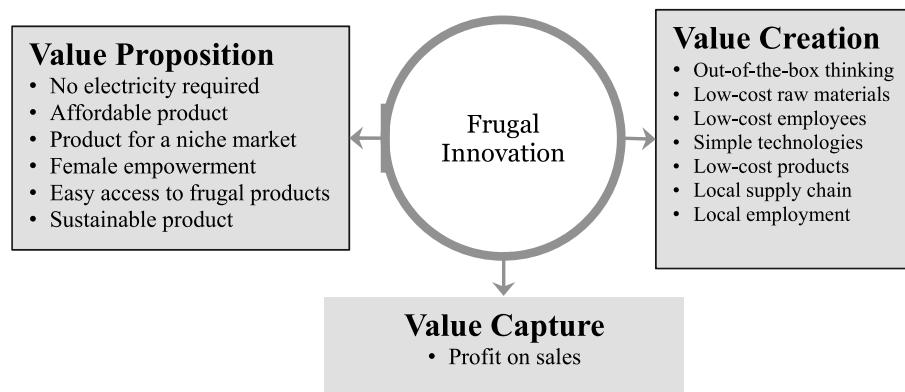


Fig. 1. A framework of sustainable business models for frugal innovation.

fibre instead of imported materials to make sanitary pads. The production mechanisms are also simple and do not involve sophisticated technologies. The use of cheap, locally available raw materials also enables enterprises to offer affordable products to low-income customers. They also received state support in many ways. For example, Gujarat state supported MittiCool with finance and other logistic supports, as expressed by the owner of MittiCool: *“If we wanted to go to Delhi to attend a trade fair, our carrying cost and hotel cost were borne by the state unless we made enough money.”* The enterprises initially focused on efficiency, namely the production of more units in less time, to create value. Later on, they improved the quality and aesthetic aspects of their products to create additional value. The owner of MittiCool expressed, *“We worked from 4:00 a.m. to 22:00 p.m. Now, the same work takes only 1 h”* He achieved efficiency by applying production techniques from another industry, namely roof tile manufacturing. The low-cost milking machine’s inventor borrowed an idea from the pressure pump spray. The sanitary towel machine was made using various mechanical and hydraulic mechanisms, but unlike multinational companies that would develop an expensive machine, Arunachalam developed a low-cost version. Arunachalam has consequently reduced the cost of sanitary pads significantly, as he expressed: *“the price of sanitary pads is one-third of the sanitary pads of multinational firms”*.

All three enterprises have employed people who may have likely remained unemployed unless they moved to another location, such as a big city. MittiCool has 30 employees, Ksheera Enterprises has 25, and Jayashree Industries has five direct employees. More importantly, these enterprises have generated thousands of indirect jobs. For example, each machine for making sanitary pads has generated employment for many women as operators, sales representatives, and so on. The enterprises also have a reputation for paying their employees a decent salary, as Mansukhbhai expressed in reply to a question about the salary of his employees: *“Yes I pay a high salary to my employees because skilled people are difficult to find and I want them to feel at home here.”* He also indicated that his work has inspired over a thousand families who are involved with selling pottery items to over a million users. He prefers his employees and community to benefit from his company rather than make more profit, although because of the location of the enterprises, salary costs are much lower than those of multinational firms. Many people also work indirectly in the value chain, however, and this also applies to Jayashree Industries and Ksheera Enterprises.

The inventors invented their products with their limited means while keeping in mind the target customers and the context of developing countries. Their personal experiences and familiarity with the target customers were an important element in developing their products. Physical proximity to the target market and a deep understanding of it are important for FI [58]. What is more, frugal products require very little maintenance. To create value and become commercially successful, all three enterprises struggled for a number of years with their inventions. For example, Mansukhbhai had been producing pans made from clay heated to a certain temperature. He experimented with different materials and combinations thereof to find the best combination of materials and temperature. He sold his products in local markets and had frequent contact with his customers, which allowed him to receive first-hand customer feedback. Some local institutes provided extra support to educate him about material properties. Arunachalam, meanwhile, tested various raw materials to identify the best materials for making sanitary pads. To create value, he used local materials to make the machine and imported the raw material for the pads. Finally, Raghava had to take a one-year sabbatical to focus on his milking machine.

A common and crucial challenge is finding the right materials or combination thereof for a product. Another key element of value creation is the use of simple technologies. Blending a knowledge of materials with innovative ideas enabled all three enterprises to solve the problems faced by low-income customers in rural areas. The mechanisms of all three enterprises’ machines are simple and easy for anyone to use.

Conventional firms often ignore these low-income customers, however. In addition, the three enterprises benefited from using local materials and local suppliers in their backward and forward supply chains. Their reputation also increased due to positive attitudes in their societies.

4.2. Value capture

The value capture for the three cases differs from that of conventional firms. They sell products at a low price yet they are of sufficient quality. The enterprises focus on cost reductions in terms of raw materials, manufacturing, and sales. To capture value, the supply chain is a key challenge for all three enterprises, because their customers are scattered across different geographical locations. Even though they have reduced production costs, delivery to distant locations hinders them from scaling up and increasing their revenues. A key way to become competitive is to reduce the price at the production point. The use of locally sourced, used, and discarded materials is a major source of cost reduction, as is the employment of cheap local labour. Another way to reduce costs is to minimize the features in a products, such as simple technologies that focus on core functionality. Since the enterprises operate at the grassroots level of developing countries, production costs are naturally low. However, informal and formal supports also help to increase the value capture through the sales aspect. Local institutional support therefore helps the enterprises to extend their reach. Awareness of their frugal products is mainly spread through word of mouth and media coverage due to their novelty. The inventions of all three enterprises have been recognized locally, nationally, and internationally, with media coverage including local news, electronic media, international media, documentaries, and even a Bollywood movie.

A challenge for the enterprises is how to protect their products from being copied by others. Due to the simplicity of their products, they are widely copied by many unscrupulous individuals. The copied products are cheaper but inferior in quality. To create extra value, the enterprises sometimes sacrifice their brand names. For example, many firms want to market MittiCool products under different names, and MittiCool agrees to this to earn further revenue. Sometimes, MittiCool even removes its logo, although it has declined to collaborate with some large firms who wanted to use their own brands instead of MittiCool.

For example, MittiCool uses “Made in India” instead of its own logo for a firm in Dubai, which is a major export destination for its clay fridge. It also sacrifices its brand name and replaces it with distributors’ brands, as the head of the sales and marketing expressed: *“First try will be MittiCool and if that does not work, then I will also go with their brand.”* To capture value, MittiCool is investing in marketing and promoting through social media to get its brand name at the top of search engine results. Thus, a way to gain further value creation is to collaborate with large firms, but the enterprises fear that these large firms may mistreat them, so they may eventually lose their own brand names. India itself is a large market, and the enterprises serve only a tiny part of it. Recently, they have started focusing on selling products through dealers, sub-dealers, and retailers. MittiCool also started selling its product through franchising arrangements in large Indian cities.

Ksheera Enterprises benefits from the milk associations that subsidize farmers in purchasing a milking machine. Jayashree Industries and MittiCool, meanwhile, receive support from well-off people—such as diabetes patients, teachers, professors, and *ayurvedic* doctors, as well as schools and universities—who advocate their products to potential customers. Even though frugal innovations are meant for low-income customers in developing countries, they sometimes trickle up to developed countries [33] in a phenomenon that is called reverse innovation [59]. Reverse innovation is therefore a new way to serve customers in developed countries with frugal products. The products of all three enterprises are exported to various developed countries including Singapore, the United Arab Emirates, and some African countries. According to the owner of MittiCool, the company has received orders from 41 countries around the world.

Arunachalam's machine has been copied and implemented in countries such as Kenya, Ghana, Nigeria, and Zimbabwe. However, he has an ambitious plan to create one million jobs by expanding his products' reach to over 106 countries. Ksheera Enterprise's machine is used in both nearby and distant countries, including New Zealand, Mexico, Sweden, and Kenya. Other unscrupulous people often prevent the enterprises from capturing value by copying their products, and the enterprises have no option but to live with this. In reality, India is a huge country, and covering the whole of it is difficult for them anyway. Moreover, intellectual property laws are weakly implemented in India, as is the case for most FIs operating at the grassroots level [1]. Arunachalam expresses this as follows: *"I put all the detail upfront on the public domain to copy. I do not worry about copying because the mission I have is to make awareness."* He also points out that the *"patent for my product is not important; I have got the patent for complacency."* A challenge for the enterprises in scaling up is the lack of government support. Arunachalam showed his dissatisfaction with this: *"I went to Harvard and one girl asked me in what way the Indian government is helping. I told them both Monmahan (prime minister) and Sonia (congress party chief) are allowing me to continue. Allowing is everything."* Despite the many challenges, all three enterprises have become successful in niche markets with sustainable business models.

5. Implications

This study demonstrates how FIs with novel business models can serve underserved customers in developing countries and play a pivotal role in sustainable development. It has examined how enterprises at the grassroots level develop a sustainable business model. We analysed three frugal innovations mainly through the lens of the three key elements of a business model: value proposition, value creation, and value capture. Thus, we have extended the current business model literature and complemented previous studies about inclusive development [43], sustainability [9], and the FI process [35]. The main value propositions comprise affordable products, natural products, electricity-free operation, focus on niche markets, female empowerment, and easy access to cheap and sustainable products. Their affordable and sustainable products therefore reach niche markets to enhance the quality of life for underserved customers while creating jobs at the local level. The enterprises also provide training to customers. FI creates new niches, including new customers, new market segments, and new means for sustainable development. Innovations for developing countries need new tailored business models for offering affordable products, so knowledge at the grassroots level is essential to meet local needs. FI lacks adequate government support, however. Arunachalam, for example, would have experienced massive sales growth if his machine had been included in the Indian government's recently declared scheme to provide free, highly subsidized sanitary pads to low-income females. This lack of support has forced the enterprises to serve their customers differently.

All three enterprises persevered in developing their FIs, often experimenting for years to develop their products. Few people would commit so much time to developing a product. To develop FIs at the grassroots level, individuals therefore need long-term dedication and technological support, which is not readily available in developing countries. Obtaining funding is also challenging for grassroots inventors. Building suitable institutes and a good environment for financial and technological support is therefore important. Due to local roots and poor transportation infrastructure, many FIs fail to scale up. Even though FIs may be patented, unscrupulous people copy them, and the enterprises cannot take legal action due to weak intellectual property protection in developing countries.

The enterprises got their funding from friends and family, private moneylenders, and banks. Due to a lack of knowledge and support from experts, they were unaware of alternative sources of funding, such as crowdfunding and venture capital. There are also some micro-venture

capitalists in India, but accessing these sources is challenging for grassroots enterprises [60]. Western start-ups, in contrast, have access to hi-tech science and technology, innovation hubs, and venture capital. Sustainability is becoming increasingly important for business and society. FIs are an effective means for achieving sustainable development, and they create new types of employment and customer segments, and they empower local people and serve niche markets. FI at the grassroots level therefore represents a bottom-up approach that is effective for sustainable development. FIs also employ business models with multi-dimensional value propositions. They therefore contribute to sustainable development more effectively than conventional products. These enterprises create value by solving the problems of people who are overlooked by large firms, all while keeping costs to minimum so that low-income customers can afford them. They also pay their employees reasonably well, even if this is extremely low by Western standards. They can therefore offer products in developing countries that multinational firms cannot [61].

This study has several implications for practitioners. It demonstrates how to solve social problems with a novel business model in order to meet society's needs affordably. Developing a frugal mind set, culture, and attitude in scholars, managers, and policymakers is essential for sustainable development. Frugal inventors at the grassroots level have in-depth knowledge about the low-income customers of developing countries, and when in dire need, affordable solutions present a precious value proposition for customers who cannot afford the existing products. FIs at the grassroots level also often do not compete with existing products because they solve problems that mainstream companies have ignored. Success usually comes after a long struggle, and enterprises need to overcome barriers that significantly differ from those of Western start-ups. FIs can also bring underprivileged people into mainstream society, so managers may need to rethink their assessment of FIs.

6. Limitations and future research avenues

This study has several limitations, thus providing opportunities for future research. It explored three FI cases, but exploring a larger number of cases could provide deeper insights into the FI phenomenon. What is more, the three cases in this study are all in India. Understanding FI in other geographical regions could add significant value to the FI literature. FI at the grassroots level for sustainable development is a recent addition to the academic literature. Indeed, sustainable business models, FI, and the economies of developing countries are all emerging concepts in the academic literature, so we have a limited understanding of SBM in this dynamic context. For example, how FIs evolve from their inception to a mature stage would be interesting and valuable to explore. How FIs at the grassroots level can successfully capture value in developed countries and the associated challenges they face in this are important study topics for the future. Business models differ between developed and developing countries, as well as between FIs and mainstream innovations, yet such differences have been limitedly explored in the extant literature. The decision-making steps of frugal entrepreneurs also differ from those of other entrepreneurs, so it would be valuable to investigate the psychological aspects of frugal entrepreneurs. Developing product distribution channels is also challenging for FIs, so exploring issues related to this may be very insightful. Financial mechanisms are also not well established for FIs, so understanding possible financial mechanisms to support FIs is essential. To develop a FI, individuals embrace an effectuation perspective in place of causation. Effectual entrepreneurs start small and grow their endeavour by expanding their networks of relationships over iterative cycles. Studies are also needed to explore how FIs can be protected from unscrupulous copying. In short, as a recent phenomenon, FI provides numerous avenues for future research.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Open Access funding provided by the Qatar National Library.

References

- [1] M. Hossain, Frugal innovation: a review and research agenda, *J. Clean. Prod.* 182 (2018) 926–936.
- [2] M. Hossain, Mapping the frugal innovation phenomenon, *Technol. Soc.* 51 (2017) 199–208.
- [3] S. Winterhalter, M.B. Zeschky, L. Neumann, O. Gassmann, Business models for frugal innovation in emerging markets: the case of the medical device and laboratory equipment industry, *Technovation* 66 (2017) 3–13.
- [4] N. Agarwal, M. Grottko, S. Mishra, A. Brem, A systematic literature review of constraint-based innovations: state of the art and future perspectives, *IEEE Trans. Eng. Manag.* 64 (1) (2016) 3–15.
- [5] M. Hossain, H. Simula, M. Halme, Can frugal go global? Diffusion patterns of frugal innovations, *Technol. Soc.* 46 (2016) 132–139.
- [6] M. Zeschky, B. Widenmayer, O. Gassmann, Frugal innovation in emerging markets, *Res. Technol. Manag.* 54 (4) (2011) 38–45.
- [7] B.C. Rao, How disruptive is frugal? *Technol. Soc.* 35 (1) (2013) 65–73.
- [8] D.A. Shepherd, V. Parida, J. Wincent, The surprising duality of jugaad: low firm growth and high inclusive growth, *J. Manag. Stud.* 57 (1) (2020) 87–128.
- [9] J. Levänen, M. Hossain, T. Lyytinen, A. Hyvärinen, S. Numminen, M. Halme, Implications of frugal innovations on sustainable development: evaluating water and energy innovations, *Sustainability* 8 (1) (2016) 4.
- [10] B. Hopwood, M. Mellor, G. O'Brien, Sustainable development: mapping different approaches, *Sustain. Dev.* 13 (1) (2005) 38–52.
- [11] E. Bucherer, U. Eisert, O. Gassmann, Towards systematic business model innovation: lessons from product innovation management, *Creativ. Innovat. Manag.* 21 (2) (2012) 183–198.
- [12] K. Dembek, J. York, P.J. Singh, Creating value for multiple stakeholders: sustainable business models at the Base of the Pyramid, *J. Clean. Prod.* 196 (2018) 1600–1612, <https://doi.org/10.1016/j.jclepro.2018.06.046>.
- [13] P. Bicen, W.H. Johnson, Radical innovation with limited resources in high-turbulent markets: the role of lean innovation capability, *Creativ. Innovat. Manag.* 24 (2) (2015) 278–299.
- [14] N.J. Foss, T. Saebi, Fifteen years of research on business model innovation: how far have we come, and where should we go? *J. Manag.* 43 (1) (2017) 200–227.
- [15] H. Volberda, O. Mihalache, C. Fey, A.Y. Lewin, Management and organization review special issue 'Business model innovation in transforming economies', *Manag. Organ. Rev.* 13 (3) (2017) 689–692.
- [16] N. Abdelkafi, K. Täuscher, Business models for sustainability from a system dynamics perspective, *Organ. Environ.* 29 (1) (2016) 74–96.
- [17] J. Child, T. Tsai, The dynamic between firms' environmental strategies and institutional constraints in emerging economies: evidence from China and Taiwan, *J. Manag. Stud.* 42 (1) (2005) 95–125.
- [18] E. Rosca, M. Arnold, J.C. Bendul, Business models for sustainable innovation—an empirical analysis of frugal products and services, *J. Clean. Prod.* 162 (2017) S133–S145.
- [19] B. Gupta, S. Thomke, An exploratory study of product development in emerging economies: evidence from medical device testing in India, *R D Manag.* 48 (4) (2018) 485–501.
- [20] G.D. Bruton, D. Ahlstrom, S. Si, Entrepreneurship, poverty, and Asia: moving beyond subsistence entrepreneurship, *Asia Pac. J. Manag.* 32 (1) (2015) 1–22.
- [21] A. Nair, O. Guldikien, S. Fainshmidt, A. Pezeshkan, Innovation in India: a review of past research and future directions, *Asia Pac. J. Manag.* 32 (4) (2015) 925–958.
- [22] R. Ramamurti, What is really different about emerging market multinationals? *Global Strategy J.* 2 (1) (2012) 41–47.
- [23] S. Corsi, A. Di Minin, Disruptive innovation... in reverse: adding a geographical dimension to disruptive innovation theory, *Creativ. Innovat. Manag.* 23 (1) (2014) 76–90.
- [24] M.B. Zeschky, S. Winterhalter, O. Gassmann, From cost to frugal and reverse innovation: mapping the field and implications for global competitiveness, *Res. Technol. Manag.* 57 (4) (2014) 20–27.
- [25] R. Howell, C. van Beers, N. Doorn, Value capture and value creation: the role of information technology in business models for frugal innovations in Africa, *Technol. Forecast. Soc. Change* 131 (2018) 227–239.
- [26] G. George, A.M. McGahan, J. Prabhu, Innovation for inclusive growth: towards a theoretical framework and a research agenda, *J. Manag. Stud.* 49 (4) (2012) 661–683.
- [27] C.C. Mutlu, W. Zhan, M.W. Peng, Z.J. Lin, Competing in (and out of) transition economies, *Asia Pac. J. Manag.* 32 (3) (2015) 571–596.
- [28] J.R. Immelt, V. Govindarajan, C. Trimble, How GE is disrupting itself, *Harv. Bus. Rev.* 87 (10) (2009) 56–65.
- [29] P. Altmann, R. Engberg, Frugal Innovation and Knowledge Transferability: innovation for Emerging Markets Using Home-Based R&D Western firms aiming to develop products for emerging markets may face knowledge transfer barriers that favor a home-based approach to frugal innovation, *Res. Technol. Manag.* 59 (1) (2016) 48–55.
- [30] C. Lim, T. Fujimoto, Frugal innovation and design changes expanding the cost-performance frontier: a Schumpeterian approach, *Res. Pol.* 48 (4) (2019) 1016–1029.
- [31] D. Ahlstrom, Innovation and growth: how business contributes to society, *Acad. Manag. Perspect.* 24 (3) (2010) 11–24.
- [32] S. Bhagavatula, T. Elfring, A. Van Tilburg, G.G. Van De Bunt, How social and human capital influence opportunity recognition and resource mobilization in India's handloom industry, *J. Bus. Ventur.* 25 (3) (2010) 245–260.
- [33] V. Govindarajan, R. Ramamurti, Reverse innovation, emerging markets, and global strategy, *Global Strategy J.* 1 (3–4) (2011) 191–205.
- [34] L.J. Petrick, S. Juntivasarakij, The rise of the rest: hotbeds of innovation in emerging markets, *Res. Technol. Manag.* 54 (4) (2011) 24–29.
- [35] M. Hossain, Frugal innovation: conception, development, diffusion, and outcome, *J. Clean. Prod.* (2020) 121456.
- [36] M. Pansera, R. Owen, Innovation for de-growth: a case study of counter-hegemonic practices from Kerala, India, *J. Clean. Prod.* 197 (2018) 1872–1883.
- [37] R.T. Krishnan, S. Prashantham, Innovation in and from India: the who, where, what, and when, *Global Strategy J.* 9 (3) (2019) 357–377.
- [38] F. Wan, P.J. Williamson, E. Yin, Antecedents and implications of disruptive innovation: evidence from China, *Technovation* 39 (2015) 94–104.
- [39] L. Annala, A. Sarin, J.L. Green, Co-production of frugal innovation: case of low cost reverse osmosis water filters in India, *J. Clean. Prod.* 171 (2018) S110–S118.
- [40] A. Pisoni, L. Michelin, G. Martignoni, Frugal approach to innovation: state of the art and future perspectives, *J. Clean. Prod.* 171 (2018) 107–126.
- [41] Y. Luo, J. Child, A composition-based view of firm growth, *Manag. Organ. Rev.* 11 (3) (2015) 379–411.
- [42] A.H. Van de Ven, R. Jing, Indigenous management research in China from an engaged scholarship perspective, *Manag. Organ. Rev.* 8 (1) (2012) 123–137.
- [43] M. Hossain, Adoption of Open Innovation by Small Firms to Develop Frugal Innovations for Inclusive Development, 2018 (Researching Open Innovation in SMEs).
- [44] S. Sarkar, Grassroots entrepreneurs and social change at the bottom of the pyramid: the role of bricolage, *Enterpren. Reg. Dev.* 30 (3–4) (2018) 421–449.
- [45] N.M. Bocken, S.W. Short, P. Rana, S. Evans, A literature and practice review to develop sustainable business model archetypes, *J. Clean. Prod.* 65 (2014) 42–56.
- [46] F. Lüdeke-Freund, K. Dembek, Sustainable business model research and practice: emerging field or passing fancy? *J. Clean. Prod.* 168 (2017) 1668–1678.
- [47] J. Prabhu, S. Jain, Innovation and entrepreneurship in India: understanding jugaad, *Asia Pac. J. Manag.* 32 (4) (2015) 843–868.
- [48] L. Massa, C.L. Tucci, A. Afuah, A critical assessment of business model research, *Acad. Manag. Ann.* 11 (1) (2017) 73–104.
- [49] M. Geissdoerfer, S.N. Morioka, M.M. de Carvalho, S. Evans, Business models and supply chains for the circular economy, *J. Clean. Prod.* 190 (2018) 712–721.
- [50] R.E. Hoskisson, M. Wright, I. Filatotchev, M.W. Peng, Emerging multinationals from mid-range economies: the influence of institutions and factor markets, *J. Manag. Stud.* 50 (7) (2013) 1295–1321.
- [51] S. Hart, S. Sharma, M. Halme, Poverty, Business Strategy, and Sustainable Development, Sage Publications Sage CA, Los Angeles, CA, 2016.
- [52] A. Dubois, L.-E. Gadde, Systematic combining: an abductive approach to case research, *J. Bus. Res.* 55 (7) (2002) 553–560.
- [53] K. Behfar, G.A. Okhuysen, Perspective—discovery within validation logic: deliberately surfacing, complementing, and substituting abductive reasoning in hypothetico-deductive inquiry, *Organ. Sci.* 29 (2) (2018) 323–340.
- [54] R.K. Yin, Case Study Research and Applications: Design and Methods, Sage publications, 2017.
- [55] K.M. Eisenhardt, Building theories from case study research, *Acad. Manag. Rev.* 14 (4) (1989) 532–550.
- [56] C. Zott, R. Amit, L. Massa, The business model: recent developments and future research, *J. Manag. Stud.* 37 (4) (2011) 1019–1042.
- [57] M. Hossain, Business model innovation: past research, current debates, and future directions, *J. Strategy Manag.* 10 (3) (2017) 342–359, <https://doi.org/10.1108/JSMA-01-2016-0002>.
- [58] S.K. Jha, I. Parulkar, R.T. Krishnan, C. Dhanaraj, Developing new products in emerging markets, *MIT Sloan Manag. Rev.* 57 (3) (2016) 55.
- [59] H. Simula, M. Hossain, M. Halme, Frugal and reverse innovations—quo vadis? *Curr. Sci.* (2015) 1567–1572.
- [60] L. Sonne, Innovative initiatives supporting inclusive innovation in India: social business incubation and micro venture capital, *Technol. Forecast. Soc. Change* 79 (4) (2012) 638–647.
- [61] G.B. Özcan, A.E.C. Mondragon, G. Harindranath, Strategic entry and operational integration of emerging market firms: the case of Cemex, Beko and Tata Steel in the UK, *J. Bus. Res.* 93 (2018) 242–254.