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Review

Frugal innovation: A review and research agenda

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ABSTRACT

This study aims to review the frugal innovation literature in order to understand the main sources, theories, and overlapping concepts, as well as the input, success factors, impeding factors, and output of frugal innovations (FIs). A systematic research approach was applied in this study to synthesize the frugal innovation literature. Using a standard research review protocol, 101 relevant articles were extracted from 11 publication databases. We found that even though frugal innovation literature is in an embryonic stage there are over a dozen of definitions of it. This study analyses various definition of frugal innovation. The FI concept overlaps with a large number of other concepts, thus hindering the pace of FI research. Combining many overlapping concepts into one - frugal innovation - would help to develop frugal innovation as a well-established discipline. The theoretical development of frugal innovation discipline is still in an early stage. Hence, theory-driven studies are necessary. FIs are emerging from numerous sources as such exploring it from various levels and units of analysis are important. FI requires a significant change in a firm's approach to innovation. It plays an important role in sustainability. Based on the analysis of the extant frugal innovation literature, this study points out research agenda.

Contents

1. Introduction

Until recently, innovations mainly originated from developed countries like the USA and Japan (McCloskey, 2010). Some scholars criticize the western model of development (see Lizarralde and Tyl

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(2017)). Many firms and individuals from developing countries are emerging with frugal innovations (FIs) (Rosca et al., 2017). FIs tend to emphasize sustainability more than the mainstream innovations (Levänen et al., 2015). Hossain et al. (2016; p. 133) define "*frugal innovation as a resource scarce solution (i.e., product, service, process, or business model) that is designed and implemented despite financial, technological, material or other resource constraints, whereby the final outcome is significantly cheaper than competitive offerings (if available) and is good enough to meet the basic needs of customers who would otherwise remain un(der)served*." There are numerous types of FIs in practice. Some prominent examples of FIs include cars, medical devices, health services, solar energy, refrigerators, and water purifiers (Hossain, 2017). GE's handheld ECG machine MAC 400 costs US$800. It has reduced the cost of an ECG scan in the developing countries like India down to just US$1.0 compared to about US$20 in the developed countries. As transportation systems are not well developed in most of the developing countries, instead of bringing patients to a nearby hospital, this portable machine can be taken a patient's place which may be far away from a nearby hospital. The MAC 400 ECG machine is also used in developed countries in places, such as emergency rooms and ambulances. Frugal innovations are being developed from the grassroots level. For example, a clay fridge Mitticool was invented by a school dropout Mansukhbhai Prajapati from Gujarat, India. The fridge costs less than US$100 and it does not need electricity and keep food items fresh for several days naturally. Frugal innovations like MAC 400 ECG machine and Mitticool fridge show a novel way to serve low-income customers. Numerous frugal innovations are successfully serving low-income customers (see Hossain, 2017).

The academic knowledge on FI is sparse (Simula et al., 2015). Frugal innovation offerings are generally good enough to fulfil the needs of local consumers in developing countries, yet they are significantly less expensive than alternative offerings (Ancarani et al., 2014; Rao, 2013). Even though such innovations are primarily aimed at low-income customers in developing countries, some of them trickle up to developed countries (Zedtwitz et al., 2015). Scholars argue that FIs aim to disrupt existing innovation paradigms with significant cost reductions on the one hand and maintain customer value on the other (Knorringa et al., 2016). The characteristics of FIs are different to those of mainstream innovations, so they need to be understood from novel perspectives. FIs therefore need different theories for several key reasons, such as (1) the geographical context is different (Rao, 2013); (2) the diffusion pattern is different (Hossain et al., 2016); (3) they need a different business model (Zeschky et al., 2011); and (4) they need a different distribution channel (Simula et al., 2015). Some scholars argue that FIs provide opportunities for firms to mitigate poverty, while others regard FIs as nothing more than a new way for capitalists to exploit underprivileged customers (see Knorringa et al., 2016).

FI has become a central innovation topic that is predominantly focused on developing countries. A significant number of studies into FI have emerged in recent years, and the FI concept overlaps with many other concepts (Agarwal et al., 2017). The research stream into frugal innovation has also proceeded in a number of paths, and the diffusion of the frugal innovation concept through the academic literature and practices has emerged in an unorganized and convoluted fashion. Several review papers on frugal innovation literature and related topics have provided some insights through distinct lenses (Agarwal et al., 2017; Hossain, 2017; Rosca et al., 2017; Zeschky et al., 2014a,b). Agarwal et al. (2017) reviewed the literature for constraint-based innovations originating from emerging economies. Hossain (2017) systematically explored various frugal innovation cases through industry-wise classification. In addition, Rosca et al. (2017) identified the role of frugal innovation in sustainability, while Tiwari et al. (2016) conducted bibliometric analyses to identify key sources of scholarly influence. They shed light on issues, such as the publication of articles over the 2010–2016 period, the most frequently used keywords, and influential authors. Pansera et al. (2017) also conducted a review of innovation concepts emerging from developing countries, with frugal innovation being one such concept. They also explored how the frugal innovation concept has evolved over the years and identified some key findings.

The above studies have certainly enriched our understanding on FIs, yet there are still numerous issues to explore to enhance our knowledge further. Our study takes a different approach. It aims to review the frugal innovation literature in order to understand how the concept is defined in the literature, what are the overlapping concepts, theoretical perspectives, and sources of frugal innovation. We adopt the widely accepted view of an input-process-output (I–P–O) framework (Ghezzi et al., in press) to explore input, success factors, impeding factors, and output of FIs. Thus, this study provides novel insights on frugal innovation literature.

The paper is structured as follows. The following section describes the method employed for the review. The subsequent section then synthesizes the frugal innovation literature, while the final section discusses the implications, limitations, and research agenda.

2. Method

This study applied a systematic literature review (SLR) approach (Tranfield et al., 2003; Hossain and Anees-ur-Rehman, 2016). The SLR approach helps to overcome a number of drawbacks of the traditional narrative literature review approach (Tranfield et al., 2003). A systematic review is rigorous, replicable, and transparent. The SLR approach comprises the following distinct steps: (1) define the research question, (2) design the plan, (3) search for literature, (4) apply the exclusion and inclusion criteria, (5) apply quality assessment, and (6) synthesize the literature (Jesson et al., 2011: p.12; Tranfield et al., 2003). Following the above steps, we defined the research question based on the description in the introduction section. Next, we planned the research protocol. We considered 11 major databases to search relevant literature (Table 1). As the search term, "frugal innovation" was used for all databases. For the ABI/INFORM Complete database, the full-text, peer-reviewed, and scholarly journals properties were selected to find articles that were academic in nature. On the EBSCO database, we also selected full-text and peer-reviewed as search limitations. On the Emeralds and IEEE Xplore databases, we did not impose any search limitations. The same search technique was also used for Sage Premier, ScienceDirect, Scopus, Taylor & Francis, and Web of

Table 1
Process and steps of searching for appropriate articles.

Databases	No. of retrieved articles
ABI/INFORM Complete	63
EBSCO	28
Emeralds	41
IEEE Explore	8
InderSciences	2
Sage Premier	24
ScienceDirect	99
Scopus	44
Taylor & Francis	63
Web of Science	63
Wiley	44
Total	479

Science. According to the categories on the Scopus and Web of Science databases, articles have been mainly published in fields, such as business and management, engineering, computer science, environmental science, medicine, and energy. As frugal innovation is a recent phenomenon, so we have not imposed any date limitations when searching. The search was conducted in May 2017. Fig. 1 depicts the overall search process for articles.

Some 479 documents were retrieved from the 11 databases, as shown in Table 1. We became aware that a large number of articles were duplicated over several databases, so we removed 98 such duplicates (i.e., those listed more than once in the spreadsheet). Of the 381 remaining documents, we removed 39 because they were interviews, short communications, or books, and as such, they were beyond the scope of our review. Next, we narrowed down the documents according to whether the term "frugal innovation" was mentioned in the title, abstract, or list of keywords. We found 97 such documents. In addition, we read the abstracts and main bodies of the remaining documents to establish whether each article focused on frugal innovation using alternative terminology, resulting in 18 more documents.

All 115 (97 + 18) articles were then uploaded to the NVivo program, which is widely used for general coding purposes (Gibbs, 2002) but also recently for literature synthesis (Hossain, 2017). We read each article thoroughly and coded the necessary findings from each document. The coding was conducted based on the objective of the study, including consideration of the framework presented in Fig. 2. I–P–O framework has been incorporated from McGrath (1964). This framework has been applied as a key foundation in various studies of management discipline (see Simsek, 2009; Ghezzi et al., in press). It helps to identify the input, output and associated success and impeding factors of the phenomenon under study. The main components of the I–P–O framework have been adopted from the studies on process models. The framework is used to review and interpret the literature and a recent literature review paper on crowdsourcing has used the framework (Ghezzi et al., in press). While adopting the I–P–O framework, we have considered the success and impeding factors as two key elements for the process part.

Coding was conducted based on pre-determined themes which have been mentioned in the introduction. We collected definition of frugal innovation under a code name – definition; another theme was labeled as overlapping concepts that aggregates concepts that overlap with the frugal innovation concept. In the selected article, we identified the other concepts that are used to explore the frugal innovation phenomenon. Theoretical issues are collected under a theme called theoretical perspectives. We identified the theories that are applied, mentioned and pointed out in the articles.

We listed various sources of frugal innovation under the sources of frugal innovation theme. Sources of frugal innovation mainly include SMEs from developed and developing countries, western multinationals, emerging multinationals, NGOs, and state organizations. Coding for sources of frugal innovation was conducted considering the above sources. In the same vein, input, success factors, impeding factors and output are used as themes to collect relevant knowledge on them. For input, we identified the key inputs that are used for frugal innovation. The factors that are considered for the success of frugal innovation are coded under the success factors. Similar approach is applied for the impeding factors. For output, we identified the key output of the frugal innovations.

Necessary memos were taken throughout the coding process. All coded texts and memos were then downloaded from the NVivo to a word file and synthesized in order to map the frugal innovation literature. In the coding process, we found additional nine articles that are cited in the reviewed articles and suitable for inclusion. Even though the FI concept was not mentioned directly in these articles, they explored the same basic context with different labels. During the coding process, 23 articles were also excluded because they did not contribute enough to warrant inclusion. Therefore, the final number of articles reviewed in this study was 101. A synthesized summary of the FI literature is presented in the following section.

3. Analysis and results

This section is organized as follows. Firstly, we comprehensively discuss the various definitions available in the existing literature. Secondly, we discuss concepts that overlap with the frugal innovation concept. Thirdly, we discuss the main theories that are employed in the literature. Fourthly, the main sources of FI are presented. Finally, we explore the input, success factors, impeding factors, and output of frugal innovation.

3.1. What is frugal innovation?

The origin of the frugal innovation concept is not clearly known. Moreover, no study in the frugal innovation literature emphatically mentioned the origin of the concept. The earliest journal paper on frugal innovation appeared on the Web of Science database was contributed by Zeschky et al. (2011). In popular press, the concept was introduced in 2010 by The Economist (economist.com/node/15879359). However, the frugal innovation concept stems from the "frugal engineering" concept coined in 2006 by Carlos Ghosn, the Chairman and CEO of the Renault-Nissan Alliance. Frugal innovation is defined in many ways (Hossain et al., 2016). We have

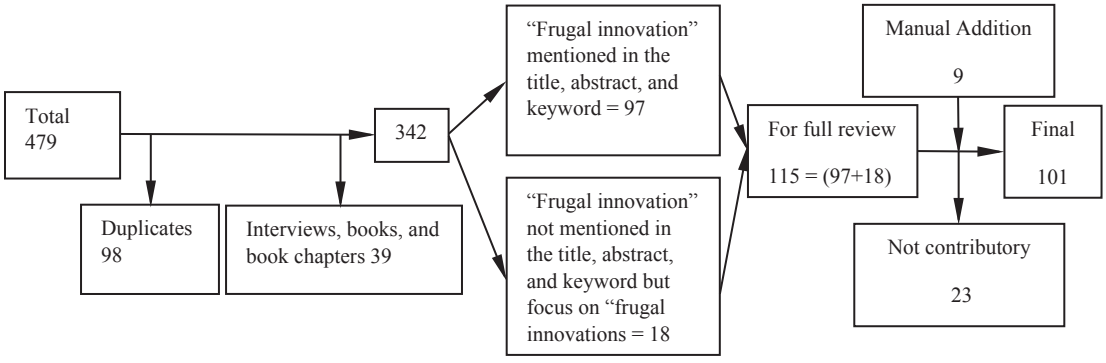

Fig. 1. The process and steps of article selection.

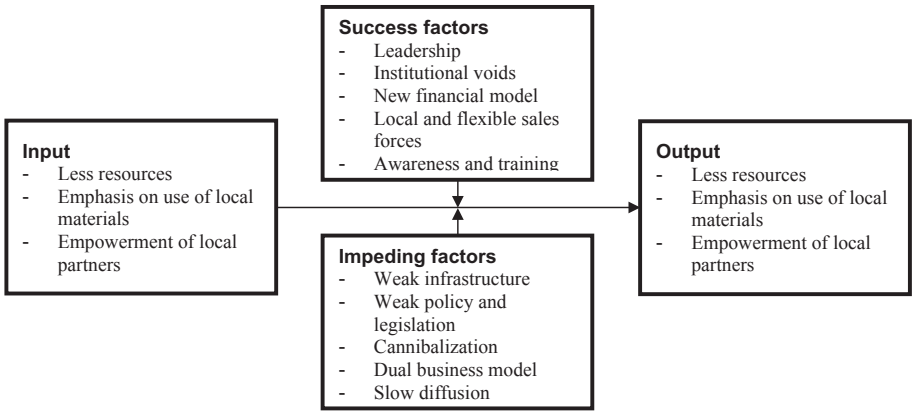

Fig. 2. A framework of frugal innovation process.

identified the definitions of frugal innovation that are mentioned in the articles. The list of the definitions has been developed based on the comprehensive search. Table 2 includes a list of representative definitions of frugal innovation.

Pisoni et al. (2017) found that the definition of frugal innovation has evolved based on three broad ways: product-oriented definition in 2012–2013, market-oriented definition in 2014–2015, and criteria-oriented definition in 2016–2017. Gupta (2012) considers FI as a new management philosophy that integrates the needs at the base of the pyramid (BoP) as a starting point to develop solutions that differ greatly from the established solutions, as cited in Brem and Wolfram (2014, p. 36). FIs result in products that are low cost but good enough, and the business models for FIs originate in, and for, developing countries (George et al., 2012). Malik and Aggarwal (2012) argue that FI is an EMNC's capability to imitate, design, and manufacture products and services using existing technologies while exploiting small-scale and flexible operations, readily accessible raw materials, and other local resources. Rosca et al. (2017) argue to define frugal innovation based on the following criteria: (1) the level of manufacturing versus the state in the respective economic area, (2) location of the main processes and part of innovation development, and (3) the direction of innovation.

Weyrauch and Herstatt (2017) reviewed the literature to find criteria to define frugal innovation. They propose the following three criteria for defining frugal innovation: substantial cost reduction, a concentration on core functionalities, and an optimized performance level. The definition of Agarwal et al. (2017), meanwhile, asserts that a frugal innovation is an affordable "good enough" quality product for resource-constrained consumers. Zeschky et al. (2014b) argue that frugal innovation entails a higher technical novelty and greater market novelty than a "good-enough" innovation. Basu et al. (2013) consider frugal innovation as an innovative process design.

Some scholars include marketing and organizational methods as elements of FI. Other scholars have defined FI in similar ways (Ojha, 2014; Paunov, 2013; Soni and Krishnan, 2014). Some scholars consider FIs as high-end technologies and services, while others tend to argue toward the "good enough" end of the spectrum. Moreover, many scholars claim that FIs are developed using locally available resources, easily accessible raw materials, and the exclusion of non-essential features. Successful FIs are sometimes characterized as breakthrough innovations (Tiwari and Herstatt, 2014). Hossain et al. (2016) provide a long and comprehensive definition

Table 2
Some representative definitions of frugal innovation.

Reference	Definition
Agarwal et al. (2017)	"Frugal innovation is "good-enough," affordable products that suffice the needs of resource-constrained consumers."
Agnihotri (2015)	"Frugal innovation refers to products and services that are developed under resource constraints."
Basu et al. (2013)	"Frugal innovation is also an innovation process design in which customers are the key focus to develop accessible, adaptable, affordable, and appropriate products."
Brem and Wolfram (2014)	"Frugal innovation has low to medium sophistication, medium sustainability, and medium emerging market orientation."
Cunha et al. (2014)	"Frugal innovation to be product innovation when there is a scarcity of affluent customers and distinguish it from bricolage, which is when material resources are scarce, and from improvisation, when time is scarce."
George et al. (2012)	"Frugal innovation is …. innovative, low-cost and high-quality products and business models originating in developing countries and exportable to other developing countries or even the developed world, often termed as 'frugal innovation'."
Gupta (2012)	"FI is a new management philosophy, which integrates the needs of the base of the pyramid (BoP) market as a starting point to develop solutions that are expected to be very different from the alternative solutions."
Hossain et al. (2016)	"Frugal innovation is a resource scarce solution (i.e., product, service, process, or business model) that is designed and implemented despite financial, technological, material or other resource constraints, whereby the final outcome is significantly cheaper than competitive offerings (if available) and is good enough to meet the basic needs of customers who would otherwise remain un(der)served".
Kuo (2014)	"Frugal innovations are products and services that focus on crucial needs, spare resource use or eliminate non-essential features in the design process."
Sharma and Iyer (2012)	"Frugal innovation stems from resource scarcity: utilizing limited resources to meet the needs of low-income customers."
Weyrauch and Herstatt (2017)	"Frugal innovation consists of three attributes: substantial cost reduction, concentration on core functionalities, and optimized performance level."
Zeschky et al. (2014a)	"Frugal innovations are typically built on new product architectures that enable entirely new applications at much lower price points than existing solutions."
Zeschky et al. (2014b)	"Frugal innovation has a higher technical novelty and a higher market novelty than good-enough innovation and cost innovation."

that considers frugal innovation as a product, service, process, or business model. We also see frugal innovation along the line of this comprehensive definition. In summary, scholars have defined FI, emphasizing traditional multinationals (MNCs), emerging multinationals (EMNCs), local firms, and the community level as sources of FI. All these definitions involve low-income customers whose main deciding factor in the purchasing decision is the price.

3.2. Overlapping concepts

The FI concept overlaps with numerous other concepts, and several studies have defined and delineated various concepts that overlap with the FI concept (see Agarwal and Brem, 2012; Agnihotri, 2015; Ahuja and Chan, 2014b; Brem and Wolfram, 2014; Christensen et al., 2006; Grover et al., 2014; Rosca et al., 2017; Zeschky et al., 2014a,b). Some of these concepts are specific to certain countries, such as Gandhian and Jugaad innovation in India, Jiejian Chuangxin in China, Gambiarra and Jeitinho in Brazil, and Kanju and Jua kali in Africa (Prabhu and Jain, 2015; Nair et al., 2015). Some are embedded in developing countries, namely BoP innovation, catalytic innovation, cost innovation, good-enough innovation, inclusive innovation, indigenous innovation, resource-constrained innovation, and value innovation (Rosca et al., 2017). In relation to FI, some concepts exist in the linkage between developing and developed countries, such as disruptive innovation, grassroots innovation, blowback innovation, reverse innovation, and trickle-up innovation (Hossain et al., 2016; Rosca et al., 2017). The last three of these concepts emphasize the flow of innovation from developing to developed countries. These various overlapping concepts have mostly developed in isolation, and this is preventing FI from becoming an established research field. Most concepts do not include the aspect of sustainability. We are aware of the fact that sustainability is a nebulous term and there are a plethora of definitions of it (Gatto, 1995). Our understanding of sustainability is in line with the following statement: sustainability means the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987).

Among the overlapping concepts, FI perhaps enjoys its closest relation with BoP innovation, although BoP innovation only focuses on poorer customers with annual incomes of less than $1500 (Hart and Christensen, 2002). In contrast, FI focuses on developing countries that include both low-income customers and an emerging middle-income segment (Hossain et al., 2016; Knorringa et al., 2016). The scope of FI is therefore clearly broader than that of BoP innovation. On the other hand, FI does include most characteristics of the other overlapping concepts.

3.3. Theoretical perspectives

Frugal innovation is in a state of infancy from a theoretical perspective. Theoretical discourse in the frugal innovation literature is sparse. Several theories are cited in the literature. However, these theories are used largely as sweeping statements without any rigorous exploration. We identified the theories that are referred in the frugal innovation literature. The main theories employed in the FI literature include resource dependency theory, diffusion theory, disruptive innovation theory, institutional theory, network theory, organizational theory, international product life cycle theory, and transaction theory. Their discussion in the literature is very limited as such any quantitative analysis of cited theories is not useful. Some studies point out to explore frugal innovation through the lens of sustainability and open innovation (Hossain, 2013, 2018). Among the listed theories, the significance of resource dependency theory, diffusion theory, disruptive innovation theory, institutional theory are crucial for frugal innovation and frequently - directly and indirectly - cited in the literature. Studies are mostly fall in the business and management category with an overlap on disciplines, such as engineering, social science, medicine, economics, and decision science, among others.

Many existing theories in their current forms are unsuitable for explaining FI (Ahuja and Chan, 2014a). Resource-based theory could be applied to understand how resource scarcity drives or impedes the innovation processes of individuals and firms. In the context of frugal innovation, resources also include the distribution and logistics systems needed to reach geographically dispersed rural inhabitants who require last-mile services (George et al., 2012). A major tenet of resource dependency theory is resource scarcity, where multiple organizations compete for identical or similar sets of limited resources (Hessels and Terjesen, 2010). Hence, resource-based theory can be used to explore FI. Rogers (2010) diffusion theory, meanwhile, argues that innovations flow from the elite class to the masses as the cost of products decreases, ultimately becoming affordable for low-income customers. FI takes the opposite path, from the masses to the elite, for diffusion (Hossain et al., 2016). Rogers' diffusion theory is therefore not appropriate in the context of low-income countries, and as such, some scholars have criticized its use (Strang and Soule, 1998; Zanello et al., 2015). It is clear that an alternative diffusion theory is needed to understand FI, one that possesses some distinct elements in terms of the communication channels, the innovation itself, the social context, and time (Hang et al., 2015).

The method of networking for frugal entrepreneurs also differs greatly from that of other types of entrepreneurs. Network theory here includes elements such as education, geography, shared identities, communal ties, and social class, all of which can influence the success or failure of frugal entrepreneurs. Frugal innovations take place in resource-scarce settings where corruption is often a prevalent issue. Governance theories, meanwhile, cover issues such as ownership, control, and compensation schemes. Moreover, they emerge in settings where agencies are very different. In many regions, national legislation is not implementable due to the dominance of social class and local communities. The agencies associated with frugal innovation are therefore different, so extending governance and agency theories into the context of frugal innovation is essential. In addition, transferring knowledge from one resource base to another is challenging due to the geographically dispersed nature of these firms. It is therefore important to push the boundaries of transaction theory to embrace frugal innovation.

Disruptive innovation theory is a better fit for exploring FI because of issues, such as price, convenience, and simplicity. FI is often disruptive, because it takes a complex and expensive product and creates an affordable version (Soni and Krishnan, 2014; Slavova, 2014). Such disruptive innovations are intended for new or less demanding applications, primarily targeting non-mainstream customers (Ahlstrom, 2010). FI also encompasses new types of institutes, so institutional theory is another promising approach to understand FI (Zeschky et al., 2014a). Indeed, this could demonstrate how and why firms in developing countries act differently in the context of institutional voids (Khanna and Palepu, 1997; Mair et al., 2012).

3.4. Sources of frugal innovation

FIs occur at the individual, group, and societal levels (Grabs et al., 2015). Several studies have listed a large number of FI cases along with their sources and characteristics (Hossain, 2017; Rao, 2013; Rosca et al., 2017). Some western multinational corporations (MNCs) have adopted FIs to satisfy low-income customers. For

example, prominent FIs from MNCs include Unilever's Purit, GE's healthcare products (ECG, ultrasound machines, Lullaby baby warmer, and Vscan), and Siemens' computed tomography scanner (Rosca et al., 2017). MNCs tend to be more involved with high-tech FIs, which serve not only low-income customers but also those with higher incomes, even in wealthier countries. For example, GE's MAC 400 ECG machine serves patients ranging from the extremely poor to the very rich (Hossain et al., 2016). MNCs have enormous financial, human, marketing, operational, and technical resources (Prabhu and Jain, 2015), which they can use together with their experience to create solutions for low-income countries (Anderson and Markides, 2007). Until recently, MNCs paid limited attention to developing products aimed at low-income customers, because there were largely unattractive to them. A key challenge to overcome is the highly fragmented nature of low-income markets and their low current value (Rosca et al., 2017).

Emerging multinational corporations (EMNCs) are better equipped to succeed with FI (Prabhu and Jain, 2015). They have enormous resources and local knowledge to develop FIs. Tata, Godrej, Haier, Vodafone, Lenovo, EasyPaisa, and Galanz are well-known EMNCs that are very successful with FIs (Hossain, 2017). Many EMNCs' main target market is the developing countries. Hence, EMNCs have more potential than MNCs for FIs. For example, Tata's Swach, Ace, and Nano (the cheapest car in the world), as well as Godrej's ChotuKool refrigerator, are popular FIs offered by EMNCs (Hossain, 2017; Lim et al., 2013; Ray and Ray, 2011). Tata's Swach, for example, has challenged Unilever's Pureit water purifier thanks to its much lower price (Levänen et al., 2015). Likewise, Mahindra and Mahindra's small tractors have outsold some established western brands in developed countries (Hossain, 2017).

Many small firms are emerging around the world with their frugal innovations. Embrace, LifeStraw, Shakerscope, and Solvatten were developed by Western startups (Hossain, 2017). Social enterprises, such as Selco, Husk Power Systems, and Grameen Bank's microfinance are also contributing significantly to sustainability (Hossain, 2017). Even though state institutions are not designed for innovation, there are many good reasons for them to encourage FIs. For example, the $50 Aakash tablet PC and the Electronic Voting Machine are two popular FIs brought by India's state institutions (Hossain, 2017). Local startups are mostly active at the grassroots level, and individuals with no formal technical education have developed FIs like the Mitticool refrigerator, the Jayaashree sanitary napkin, and the Ksheera milking machine (Hossain, 2017). Thus, FIs have emerged from a wide variety of sources.

The following four subsections are based on I-P-O framework (Fig. 2). Using the framework, we identified the input and output of frugal innovation. Moreover, we identified the success and impeding factors as elements of the process part of the framework.

3.5. Input

A key input for FI is the use of fewer resources, so the cost of a FI is affordable to low-income customers. The cost can be reduced in several ways, such as reusing old materials, using locally available materials, eliminating unnecessary product features, and reducing maintenance costs, among others. For example, Chinese company BYD can produce its lithium-ion batteries for 70% less than competitors in western markets (Zeschky et al., 2014a). Likewise, Chinese harbor crane manufacturer ZPMC can hire 40 times more engineers in China than its counterparts in Germany for the same cost (Williamson and Zeng, 2009), enabling ZPMC to offer products at a very low price. Many EMNCs have gained cost advantages through local low wages, local resource sourcing, and efficient operation (Williamson and Zeng, 2009). Small-sized products can also increase the affordability for some low-income customers. Multinationals like Unilever and Godrej offer their soap powders in smaller packets to meet the needs of underserved customers in developing countries (van Beers et al., 2012). The use of local materials also helps firms to reduce their production costs. Indian conglomerate Tata introduced a water purifier called the Tata Swach in 2009. Locally abundant rice husk ash is a key material for the Swach's water purification (Levänen et al., 2015). Similarly, the clay-based refrigerator MittiCool was developed in India using locally available clay and rice husk (Hossain, 2017).

The concept of frugal innovation emphasizes the use of readily available local materials, resulting in low-cost products (Hossain et al., 2016). GE's handheld ultrasound machine, as well as its Mac 400 and Mac 800 electrocardiogram machines, was developed by a dedicated independent business team based in China and India. In general, thanks to their proximity to the target market, local companies understand the customers' needs better than Western companies do. For example, Indian conglomerate Godrej developed a portable, battery-run refrigerator called ChotuKool that can be used when there is an erratic, or even no, power supply. Western technologies and support from headquarters play a key role in many frugal innovations. For example, the Tata Nano was developed with enormous input from western sources. In addition, raw materials to manufacture the low-cost Jayaashree sanitary napkin are sourced from western countries (Hossain, 2017). Along with high-end innovations there are many frugal innovations made entirely from local materials.

Another significant input is the empowerment of local partners. General Electric, for example, empowered its subsidiaries in China and India, and this resulted in several frugal innovations, such as MAC400 ECG machine, handheld ultrasound machine, and the Lullaby baby warmer (Hossain, 2017). State and international organizations also play a pivotal role in empowering local partners and individuals to develop frugal innovations (Gupta, 2012). Furthermore, active participation of citizens in the frugal innovation process enables small local entrepreneurs to customize their products and services to fulfil the needs and price expectations of their customers (Annala et al., 2018). In summary, frugal innovations are emerging with an emphasis on lower resource needs and the use of local and/or recycled resources. With high-tech frugal innovation, collaboration between western companies and local companies in developing countries is pivotal for success.

3.6. Success factors

Predicting success is difficult and more challenging for FIs (Manceau and Morand, 2014). The resource-constrained environments of developing countries provide fertile ground for FIs to grow (Zeschky et al., 2011). MNCs need to understand FI and how they can influence the rules and regulations in unstable and unpredictable places. Sako (2009) therefore argues that MNCs can develop FI through strong collaboration with subsidiaries and local firms. Innovation teams need to follow untrodden paths to develop successful FIs that target highly price sensitive customers (Tiwari and Herstatt, 2014). Jha and Krishnan (2013) point out that R&D centers need to move from their existing technical capabilities to develop an intimate understanding of the business environment. Accordingly, a substantial shift in mindset and capability is necessary for that purpose. In many cases, a local FI can diffuse to distant geographic regions (Petrick and Juntiwasarakij, 2011; Hossain et al., 2016).

Cost reduction by defeaturing existing high-end products is not enough. The addition of innovative features to fulfill local requirements is also needed (Agarwal and Brem, 2012; Zeschky et al.,

2014a). The transfer of technical knowledge and local market knowledge is also an important factor. To succeed with FIs, firms need to think frugally and bring about change in the mindset of employees by modifying the organizational culture (Agnihotri, 2015). Value analysis, target costing, and quality function deployment are essential issues for FI (Zeschky et al., 2011).

FIs are inspired by a desire to solve local challenges (Douglas, 2013), but the transfer of knowledge is important for the suitability of any particular FI approach (Altmann and Engberg, 2016). Localization and core value identification are key success factors for MNCs in emerging markets (Agarwal and Brem, 2012). The successful creation, development, and commercialization of an FI require proximity to the local markets throughout the value chain, team formulation, and marketing (Agarwal and Brem, 2012).

Along with design, the utilization of local entities is also essential for FI (Bolanos, 2013). New models of collaboration between entities in developed and developing countries can help accelerate the adoption and increase the success of frugal innovation (Dandonoli, 2013). The success of an FI lies in having the institutional discipline to put aside disappointing projects and search for new promising approaches (Denning, 2014). Instead of promoting secrecy and protecting IP, large firms need to be open about their activities and rethink the assumptions they take for granted (Hossain, 2013; Fréry et al., 2015). IP protection and the rapid and successful use of external partners are essential (Horn and Brem, 2013). Supporting infrastructure, which is generally very poor in developing countries, is also needed to turn innovative ideas into successful marketable products (Sood and Szyf, 2011). Being close to universities and reinforcing their role in society (Manceau and Morand, 2014), as well as committing to a local presence, are also important for a successful FI (Petrick and Juntiwasarakij, 2011). Local competency is indeed crucial for FI (Rosca et al., 2017). The success or failure of FIs also depends on market-specific knowledge (Grover et al., 2014). The managers of MNCs and local firms need to form mutual alliances to accelerate the pace of FI development and meet the needs of low-income customers (Agnihotri, 2015). Moreover, it is crucial that local people with first-hand experience of the product's target market are integrated into the R&D team (Zeschky et al., 2011).

MNCs also have limited knowledge of the local context (Khanna, 2015). MNCs need to understand the varying consumer needs and preferences of different regions. Proper branding, for example, can overcome cultural disruption and set appropriate targets (Panda, 2014). Pansera and Owen (2015) urge to redesign the existing technologies in a novel and frugal fashion, combined with innovative financial mechanisms for low-income customers. Deep engagement in emerging markets is another prerequisite for MNCs to succeed with FIs (Ramamurti, 2012). In addition, they need to build relationships with host governments and other public and private bodies, as well as satisfy local consumers (OECD, 2010; Sako, 2009). The private sector, including NGOs and social enterprises, serve low-income customers in the face of challenges, such as lack of finance, technical expertise, and knowledge (OECD, 2010). Successful FIs involve working within constraints (Singh et al., 2012). FI can show ways to succeed in a price-sensitive and volume-driven market with slim margins (Tiwari and Herstatt, 2013). Zeschky et al. (2011) point out that low-cost manufacturing, simple design, low-cost materials, and basic functionality are keys to serve low-income customers.

3.7. Impeding factors

FIs are developed under various constraints, so a range of impeding factors is associated with these innovations. For MNCs, developing FIs that meet the needs of low-income customers is still a daunting task (Ray and Ray, 2011). Serving underprivileged customers is not easy, both technically and organizationally (Parthasarathy, 2013). Lack of suitable and reliable sales and distribution channels is also a major impeding factor for FI (Simula et al., 2015). Zeschky et al. (2011) argue that MNCs must restructure their established business models by integrating resource-constrained consumers and building organizational structures and capabilities for FI. Policy makers are also facing challenges to sustainable growth (OECD, 2010), so they increasingly emphasize the FI development. FIs mainly emerge in places with weak institutes and lax legislation (Zeschky et al., 2014a). Combining economic value with environmental and social benefits is another key challenge to ensure the success of a business model (Rosca et al., 2017). Scalability is yet another key issue for FI (Rosca et al., 2017; Wohlfart et al., 2016). MNCs fear that the presence of high-end innovations alongside FIs in the same region may result in self-cannibalization (Angot and Plé, 2015; Wohlfart et al., 2016).

Diffusion is also a key challenge for FI, especially in the face of market failure and lack of support (Paunov, 2013). Sako (2009) argues that MNCs face difficulties when engaging in FIs that require profound understanding of unserved consumers and the host governments who provide permission, licenses, intellectual property rights, regulation for foreign direct investment, etc. Innovating in, and for, developing countries is more difficult because of resource scarcity, weak infrastructure, limited access to this infrastructure, and financial constraints (Ahuja and Chan, 2014a). Levänen et al. (2015) argue that firms face three main challenges: (1) the proper integration of material efficiency, (2) inclusive local production employment and decent work for all, and (3) inclusive and sustainable local industrialization.

Lack of market inclusiveness in innovation results in sheer market failure. The low and unstable incomes of an FI's target customers are a fundamental hindrance to develop a well-balanced market. In other words, a lack of business acumen among local partners and varying market characteristics are critical issues to address (Angot and Plé, 2015; Altmann and Engberg, 2016). Limited education, inadequate infrastructure, and fragmented distribution systems significantly impede the diffusion of FI (Kahle et al., 2013; Parthasarathy, 2013). Core value identification to serve low-income customers is also limited. Developing a frugal mindset and culture can also be challenging in western countries where radical innovation is commonplace (Agnihotri, 2015), and top management may be reluctant to allocate resources for FI (Angot and Plé, 2015).

MNCs are often not prepared for, and sometimes not sensitive to, some of the demands that emerge from target markets. The R&D centers of MNCs can face difficulties that conflict with the success of FIs (Altmann and Engberg, 2016). For example, firms may struggle to convert technology innovations into viable business propositions because of cost, IP, and other issues (Ahuja and Chan, 2014a). Developing countries are prone to deficiencies in capital, skilled resources, lawmaking steps, law enforcement, judicial processes, and technology adoption (Barclay, 2014). Even though FI is intended for low-cost customers, durability, reliability, and maintainability with local skills are all necessary (Petrick and Juntiwasarakij, 2011). Individuals represent the primary knowledge repository in organizations, but a key concern is how to integrate this knowledge at the organizational level (Tiwari and Herstatt, 2014; Schneckenberg et al., 2015).

3.8. Output

One key outcome of frugal innovation is affordable products (Rao, 2013). For example, the Tata Nano is the cheapest car at

$2500, having been developed by an Indian conglomerate in the spirit of frugality (Ray and Ray, 2011). Similarly, General Electric's Mac 400 is a handheld portable ECG machine with a simple mechanism, and it is available at a significantly lower price point than its alternatives (Hossain et al., 2016). There are also low-tech, simple frugal innovations—such as the Mitticool clay fridge, the Ksheera milking machine, and the Jayashree sanitary napkin—that have emerged at the grassroots level (Hossain, 2017). Many of these frugal innovations play a key role in addressing local problems (see Rosca et al., 2017). Frugal innovations as affordable products and localized solutions have opened up new markets and provided new sources of revenue, not just for local companies but also for MNCs. A large number of unserved customers have benefitted from frugal innovations.

Another notable contribution of frugal innovation is sustainable development. By sustainable development we mean to achieve a desired state of a society where living conditions and resource use continue to meet the human needs without compromising the stability of natural systems. Levänen et al. (2015) found that frugal innovations are more sustainable than their alternatives. Organizations such as Selco, Husk Power Systems, Grameen Bank's microfinance contribute significantly to the sustainable development (Hossain, 2017). A key strength of FI is indeed its ability to solve sustainability challenges (Basu et al., 2013).

FI provides novel opportunities for large firms to generate new revenue streams (Simula et al., 2015). It also promotes enterprise and nurtures the entrepreneurial environment in new regions by creating new business models, particularly those aimed at providing affordable products and services to customers (Winterhalter et al., 2016). FI creates social enterprises that involve new types of employees (Levänen et al., 2015), and it scores high in terms of the price-performance ratio. FI has therefore placed MNCs in a dilemma, and many are restructuring their business strategies in response. In 2011, Unilever set itself a bold objective of doubling its revenues by 2020 while simultaneously reducing the environmental impact of its products by using more raw materials from sustainable sources and trucks with lower emissions to distribute its products. FI also provides opportunities for EMNCs to increase their market shares. In addition, many small enterprises emerge in local regions, and these enterprises are very agile in serving at least their local customers (Radjou et al., 2012). In general, FIs are considered environmentally friendly and resource conservative (Agnihotri, 2015).

FI also advocates the reuse of old and recycled materials (Bolanos, 2013), thereby saving energy and resources. It has a positive societal impact on democratization, economic empowerment, and social development (Kahle et al., 2013) by fulfilling basic needs like food, healthcare, water, and transportation in developing countries (OECD, 2010; Hossain, 2017). Another outcome of FI is its promotion of horizontal mechanisms for developing and delivering products and services (Pansera and Sarkar, 2016). FI is a way of maximizing the value derived from limited resources (Singh et al., 2012). It also stimulates the development of associated infrastructure and reduces institutional voids (Simula et al., 2015). It favors organizational learning (Angot and Plé, 2015), provides economic and social benefits, and conserves natural resources, such as materials, energy, and water. Radjou et al. (2012) consider FI as a creative form of democracy, one where people lead innovation.

FI contributes to inclusive growth, reduces inequality, facilitates societal empowerment (Kahle et al., 2013), and creates social value. It even provokes high-income customers to change their mindset toward cheaper products. It helps alleviate people from poverty (Kahle et al., 2013). Greater emphasis on simple yet abundantly available technologies is a key part of the FI mantra (Sharma and Iyer, 2012). FI advocates not only solving the problem with minimum resources but also reducing the consumption of resources (Agnihotri, 2015; Rosca et al., 2017), thus offering a sustainable impact. FI also gives opportunities for MNCs to generate more revenue from low-income customers (Agarwal and Brem, 2012), and it promotes awareness of sustainable development among the governments and state institutions of developing countries (Bound and Thornton, 2012).

4. Implications, limitations, and future research

4.1. Implications

This study has several implications. We listed the salient definitions of frugal innovations. Even though frugal innovation discipline is only six years of old there are over a dozen of definitions of frugal innovation. Definition diversity remains in all concepts. For example, sustainability has numerous definitions, each differs from the other. Thus, it is time to focus on exploring the phenomenon by focusing less on defining the frugal innovation concept.

Frugal innovation overlaps with numerous other concepts, and this has hindered the development of FI as a well-established research discipline. Even though some studies have attempted to separate the concept of frugal innovation from other related concepts, its boundaries are still not well established. The academic and managerial discourse on frugal innovation is still in its embryonic stage.

The frugal innovation phenomenon can be explored using numerous theoretical perspectives, and some studies have referred to various theories that could be used to explore FI. Sadly, no study has rigorously applied any of these theoretical perspectives to explore FI. Instead, almost all studies are explorative and qualitative in nature, and no conceptual and qualitative studies offer propositions for subsequent testing. Moreover, no quantitative studies exist. FI requires new forms of business models, networks, alliances, and collaborations, so the existing theories, as they are now, are unsuitable to understand FI.

Resource scarcity, weak institutes, and underdeveloped infrastructure work both as impeding and success factors for FI. Unlike mainstream innovations, FIs emerge from a variety of sources with varying degrees of sophistication, so framing various types of FI into a standard structure is challenging. A careful approach is therefore needed for firms to enjoy success with FI. Understanding frugal innovation in terms of their sources is crucial. For example, frugal innovations of MNCs are high-tech, sophisticated in nature whereas frugal innovations of grassroots entrepreneurs are low-tech and naive.

Inputs of frugal innovations predominantly are the use of fewer resources, reuse of materials, use of locally abundant materials, include minimum product features with low cost and easy maintenance. Therefore, inputs of frugal innovations are different from the conventional products. They need different supply chains, suppliers, and skilled people. A substantial change in mindset is necessary for companies to spur frugal innovation. Organization culture and business environment both need to be considered simultaneously for frugal innovation. The success of the frugal innovation phenomenon lies in its potential to diffuse in dispersed geographical regions.

Establishing and maintaining reliable sale and marketing channels are key barriers to the diffusion of frugal innovation. For frugal innovation, large firms may need dedicated business models which may threaten their conventional business models and cannibalized their products. Companies need to develop deep understanding of the target market and intellectual property as the intellectual property legislation and their implementations in many

target markets are not well established. Firms need to collaborate with host governments, regulatory agencies, and pressure group to keep every party on board for their business. The target customers of frugal innovation are highly price-sensitive and they demand affordable but quality products. For example, Tata Nano has compromised the quality standard to develop the cheapest car in the world. Developing adequate infrastructure and distribution systems are prerequisite for frugal innovations.

The success of FI lies predominantly on the price of offerings, although a novel business model could mitigate the price sensitivity of customers. Aside from the outcomes produced by mainstream innovations—such as revenue, new technologies, and employment—FI has some additional outcomes, such as new sources of revenue, local entrepreneurship, new forms of employment, better utilization of resources, and affordable products. Thus, FI plays a significant role in sustainable development. Firms differ in their goals for inclusive innovation—some may consider it a social responsibility, while others are driven by an economic or political objective. Along with financial aspects, frugal innovations offer several social aspects. Frugal innovation brings low-income people into the affordable and mainstream groups through affordable products. Thus, organizations with frugal offerings contribute towards the social aspects. Frugal innovations empower women who can use, for example, affordable sanitary napkins and live with dignity. FIs create awareness on social taboo. People who, for example, have no access to electricity can still have an option to preserve their food items for several days in a clay fridge or battery-run fridge. Frugal innovations provide accessibility to quality healthcare from the door-step of the people who live in remote areas.

There are adverse outcomes of frugal innovation. For example, Tata Nano car has failed in crash test and to attract adequate customers of the target segment because of poor's car perception. It has received a zero-star adult protection rating and failed to meet the basic UN safety requirements. Moreover, many organizations are using frugal innovation to profit from the low-income customers with the sustainable development claim. Sachet packaging of a small amount of products, such as shampoo, toothpaste, and conditioner allows the low-income people to afford these products as the low-income customers can not afford a bulk amount of such products. Sachet packaging typically made of a thin film of aluminum and plastic. The problem is that Sachets are a waste nightmare and sachets clog drains and contribute to flooding. Hence, frugality has various adverse impacts on sustainability. As a whole, frugal innovation plays an important role to offer affordable products for low-income customers.

4.2. Limitations

This study has several limitations. "Frugal innovation" was the sole keyword used to search articles, so some relevant papers may not have been included in this study. This study also considered articles written only in English. FI is dominant in local contexts, especially in developing countries, and valuable publications may exist in languages other than English. Including these non-English publications may well bring a richer understanding of FI. In addition, the search may have overlooked some articles that explored the same phenomenon using different terms, even though a very comprehensive search approach was applied. Considering these limitations and the synthesis of the literature, this study provides research agenda.

4.3. Research agenda

The study shows that there are numerous research opportunities for FI. Considerable research is needed to understand various facets of frugal innovation especially when FI is in a very nascent stage in the academic and managerial discourse. Future studies may consider the theories that are highlighted in this study and beyond. Exploring how resources can be deployed to enhance or impede FI is an area where resource-based theory could be deployed. Frugal innovation is developed using different types of resources. Unit of analysis is a key issue to consider in the future research. Unit of analysis may include entities, such as individuals, firm, industry. Furthermore, individuals can be highly educated or illiterate: firms can be small, large, MNCs, and EMNCs. These entities have different challenges and opportunities.

How do firms harness and internalize FI initiatives successfully (George et al., 2012), and how do maverick individuals turn institutional and resource constraints into business opportunities? In addition, how do large firms develop both top-down and bottom-up types of innovations simultaneously and integrate them into local contexts with limited resources? FIs often depend on the innovation itself rather than the inspiration for the innovative activity, but which performance outcomes constitute success for an FI? Should the success of FIs and mainstream innovations be measured using the same yardstick when organizations initiate FIs? Moreover, relating FI with other concepts like open innovation may help widen our understanding of this concept (Hossain, 2013).

Typically, revenue is used to measure the success of an innovation, but there is an increasing consensus to assess an innovation based on its societal impact. It is essential to understand whether an FI has a better societal impact than the alternative innovations. The proximity of MNCs to the target market is also essential, especially when poverty and resource scarcity may influence partner choice or dependence. In addition, when MNCs have both mainstream and frugal innovations in the same market, they need to use a dual business model for each form of innovation (Winterhalter et al., 2016; Zeschky et al., 2014b). How to practically implement such a dual business model is rarely discussed in the literature. In addition, the literature about innovation in local enterprises is sparse. MNCs need to collaborate with new types of organizations to develop FIs, and this could be explored through the lens of agency theory. In some cases, FI requires collaboration between large and small firms, but the existing literature provides little knowledge about the forms of collaboration that should take in practice. Even though frugal innovations clearly contribute to sustainable development by providing affordable products to low-income customers they have negative sides which have not explored at all in the extant literature. Hence, exploring the negative sides of the frugal innovation is essential to understand FI from a holistic perspective.

FI emerges from new sources and in fresh environments, and as such, government regulation and policy can help or hinder frugal innovation efforts. Moreover, the physical and technical infrastructures play a key role for FI (Zeschky et al., 2011). So, exploring these factors is essential to enrich our understanding of FI. Transferring knowledge is also crucial for FI, yet there is very limited empirical evidence for the transfer and implementation of frugal practices from one context to another. Moreover, some scholars claim that FIs are disruptive in both developed and developing countries, so extensive exploration is needed to verify this claim. Policy and political impacts are also very important aspects of FI that warrant further study. Anecdotal evidence indicates that FI has significant societal impacts, yet firm evidence for this societal impact is limited. The share of innovation coming from developing countries is increasing, and these innovations take paths that are very different from those of traditional innovations. The diffusion pattern of FI also differs from mainstream innovations as such, diffusion theory needs to be extended to encompass FI.

Many FIs emerge from informal sectors, so another important avenue for future research is to address how such innovations can be linked with formal innovations. The current FI literature emphasizes products and features but developing frugal mindsets and cultures within organizations is important (Zeschky et al., 2011).

Developing frugal innovations by large companies need a different approach. How companies can develop the process of new product development and design product architecture to foster frugal innovation is an interesting research avenue. What drives and hinders frugal innovation development in the large organizations are limitedly known in the current literature. Another interesting issue is to explore the mindset of developed and developing countries to develop and foster an environment for frugal innovation. Several frugal innovations have turned into reverse innovation by tickling up into developed countries from developing countries. Hence, exploring this new phenomenon is important in the future. This study attempts to synthesize the current research and provides research agenda toward developing the academic knowledge and industry practices surrounding the FI phenomenon.

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