Chapter 17
Towards an Analysis of Frugal Innovation: An Important Way to Achieve Sustainability

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Abstract This research seeks to analyze the scientific publications on frugal innovation regarding the context, focus, sector in which they are operationalized, method adopted, innovative practices, benefits and contributions to society. A systematic literature review was conducted, focusing on the mapping of the specificities of publications on frugal innovation. Our results show an emerging theme that has grown substantially over the last three years. Frugal innovation has generated significant changes for people, especially in the aspect of products and services offered to society. The societal benefit of frugal innovations in socially vulnerable communities still has potential for exploration in forthcoming studies, particularly with regard to tangible indicators of impact measurement. Despite the gradual evolution of publications on the theme over the years, the focus of the studies is still centered on conceptual investigations and descriptive case studies. Some propositional and evaluative approaches appear in the studies, but there is still a need to use management theories to instill an awareness of management precepts that recognize the social dynamics of the operationalization of frugal innovation. Future studies can

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generate breakthroughs with analytical categories that explore the perspectives of a resource-based view: institutional theory, contingency theory, learning theory, and actor network theory.

Introduction

Frugal innovation emerged in the late 2000s as an appropriate for-profit technology (Kaplinskly 2011). The movement emphasizes the role of the private sector, which is a key innovation partner in the contemporary global economy and the economy operating in developing nations (United Nations 2015). Frugal innovation brings together multiple stakeholders from formal and informal sectors in geographic regions and combines their contributions with bottom-up approaches (Knorringa et al. 2016). It can contribute to the development of remote communities in developing countries with its localized, easy-to-maintain, and simple-to-implement solutions (Rosca et al. 2018), and it can also be successfully implemented in transition economies (Tian et al. 2019).

The literature associated with frugal innovation reveals a number of characteristics of the concept. The most commonly cited characteristics include these descriptors: functional and focusing on the essential; considerably reduced initial purchase cost; lower cost of ownership; minimization of the use of material and financial resources; user friendly; robust, of high value and quality; and possible to be commercialized in scale (Rosca et al. 2018). Frugal innovations are products that target emerging middle-income consumers and producers in developing economies (Knorringa et al. 2016). Substantial cost reduction, a concentration on core features, and optimized performance are criteria for classifying an innovation as frugal (Weyrauch and Herstatt 2016). Zeschky et al. (2014), in turn, classify frugal innovation using the criteria of technical novelty and market novelty. Soni and Krishnan (2014) define frugal innovation as a monolithic entity of three types: innovation as a mentality or way of life, as a process, or as a result in the form of products or services.

Frugal innovation allows for more inclusive development processes by meeting the following assumptions: the production and marketing of more economical products and services, the engagement of low-income actors in value chain activities, and natural resources being utilized in a frugal way (Baud 2016; Knorringa et al. 2016). Frugal innovation has a medium level of sophistication, medium sustainability, and medium emerging market orientation (Brem and Wolfram 2014).

Although the scientific literature presents previous studies conducted in the form of systematic literature reviews, Rosca et al. (2018) developed a systematic review of literature that analyzes current research to relate the constructs of frugal innovation and sustainable development. They highlight approaches and conditions in which frugal innovations contribute to sustainable development. Wehn and Montalvo (2018) drew up a special issue on the dynamics of water innovation. Weyrauch and Herstatt (2016) developed a systematic review and interviewed 45 company managers from different research institutes to determine what frugal innovation is and what it is not.

Tiwari et al. (2014) developed a study whose objective was to examine the use of inventive analogies in the creation of economic solutions and their impact on the project result. Brem and Wolfram (2014) published a study in which they sought to distinguish frugal innovation and related terms such as frugal engineering, constraint based innovation, Gandhi innovation, jugaad innovation, reverse innovation, catalytic innovation, grassroots innovation, and innovation in indigenous communities. The authors consolidated a conceptual framework based on a literature review of 363 previously published articles on innovation. Its structure classifies frugal innovation and related terms using three aspects: sophistication, sustainability, and orientation to emerging markets.

Several empirical studies, such as Pansera and Sarkar (2016), explored several cases of green technologies and frugal innovations driven by local entrepreneurs in the energy sector and pursued how new technologies generate jobs, income, and productivity. Anurag (2018) explains the indigenous innovations and also makes it accessible to a wider audience. Prashantham and Kumar (2019) explains that the context of startups represent "business as unusual."

We understand that there are still gaps in the literature on frugal innovation, especially in the areas of development, types of innovation, and the main contributions generated for society. These topics are especially relevant, because Pansera (2013) points out that frugal innovation minimizes the role of government and Knorringa et al. (2016) finds that frugal innovation can fill important service gaps in cases in which the government has failed. Thus, our study seeks to contribute to the systematization of data that will allow us to understand in greater detail the specificities of scientific publications dealing with frugal innovation, a subject so relevant to society.

After this introduction, we present a theoretical section that recaptures recent studies and theoretical aspects pertaining to the topic of frugal innovation. Section "Methodology Procedures" of the article details the methodological course followed to elaborate this systematic literature review. Section "Presentation, Analysis, and Discussion of Results" presents, analyzes, and discusses the research results. Section "Final Remarks" offers final considerations of this research and highlights the results' implications for the different stakeholders of the organizations. We conclude with the references that were consulted to elaborate this work.

Frugal Innovation

Frugal innovation provides solutions in remote sites that cannot be achieved by regular local government initiatives (Prabhu and Jain, 2015). Frugal innovation has the potential to bring together public and private sectors for the creation of learning and knowledge (Kahle et al. 2013). Scholars often connect the discourse of frugal innovation with elements of technological development (see Rosca et al. 2018). Therefore, a vital perception is that the state and citizens can play an important role in the innovation cycle, especially in one that meets emergency demands of vulnerable people (Wehn and Montalvo 2018).

Innovation is linked to sustainable development by: (1) reducing resource use at various points in the production and consumption chains; (2) providing renewable resources and technologies to billions of low-income consumers; (3) influencing product design to promote green and life cycles; (4) encouraging ecological awareness and education; and (5) furthering frugality as a mentality (Rosca et al. 2018). Frugal innovations often create positive ecological impacts beyond their value propositions, because they engage local communities in education and awareness campaigns (Rosca et al. 2018). Initially, frugal innovation studies emphasized consumers moving from the bottom of the pyramid to the middle class in emerging markets (Soni and Krishnan 2014). However, more recent studies have focused on the economic use of resources in process innovation, which allows the creation of products, services, and environmentally-friendly, high-quality systems to be accessible to low-income people (Wehn and Montalvo 2018).

Frugal innovation has direct effects on the health of low-income actors (Howitt et al. 2012). Examples of implementations generated by frugal innovation in society include eRanger ambulances, water purifiers, clean cooking stoves, car air purifiers, management of solid wastes and effluents, and sanitation systems (Rosca et al. 2018; Uduji and Okolo-Obasi 2018; Raimi et al. 2019). In addition, Nahi (2016) argues that frugal innovations in sectors such as energy or health care have a major impact on quality of life and enable social growth. Analogies can have a significant impact on the successful development of frugal innovations in environments characterized by severe resource constraints and high price sensitivity. For example, the development of a frugal artificial heart was based on the heart structure of cockroaches; this frugal device led to a cost reduction of some 20 times (Tiwari et al. 2014).

The use of frugal innovation as a management philosophy brings a different approach to increasing the quality of life; there is a greater emphasis on free time and self-realization than on materialism and consumption (Roiland, 2016). At the same time, frugal innovations initiated by multinational or local firms have the potential to increase low-income economic access to critical products and services and to address inequality in labor markets (Rosca et al. 2018).

Frugal innovation increases accessibility, ensures impact in social settings, and uses limited resources. The active role of citizens as co-producers in the innovation process allows small-scale local entrepreneurs to tailor their products and services to their customers' needs and price expectations (Wehn and Montalvo 2018). The specific attributes of frugal innovations depend heavily on the defined context, such as the environment, the specific needs, or the market structure (Weyrauch and Herstatt 2016). Lastly, social responsibility initiatives in organizations influence the organization's license to operate in the Ghanaian business environment (Famiyeh et al. 2019).

Methodology Procedures

This study consists of a systematic literature review. A four-step approach according to Tranfield's methodology (2003) was followed to conduct this study.

Figure 1 illustrates the steps that were followed to conduct this study. In Stage I, several databases were researched to map the existing scientific publications on the topic of frugal innovation. The key search terms were "frugal innovation" in the Portuguese, English and Spanish languages. Only one key search term was used, since, in consultation with specialists, no other term was mapped in the academic literature that could be a direct substitute for frugal innovation. Although it is generally recommended to conduct systematic literature reviews with multiple key search terms, this research only adopted the one term that best expresses the mapping of scientific literature that could answer the objective of our study: to analyze the scientific publications on frugal innovation's context, focus, sector in which it is operationalized, method adopted, innovation practices, benefits and contributions to society. The search for the articles occurred by mapping the titles, abstracts, and keywords of the studies. The types of material mapped were articles, articles in press, reviews, and research articles. The databases consulted were Scopus, Web of Science, Sage, and Science Direct, and the time of publication selected was 2008–2018. The first search provided a map of 350 academic articles.

In Stage II the articles were read in full and a spreadsheet was completed taking into account the categories of analysis described in Table 17.1.

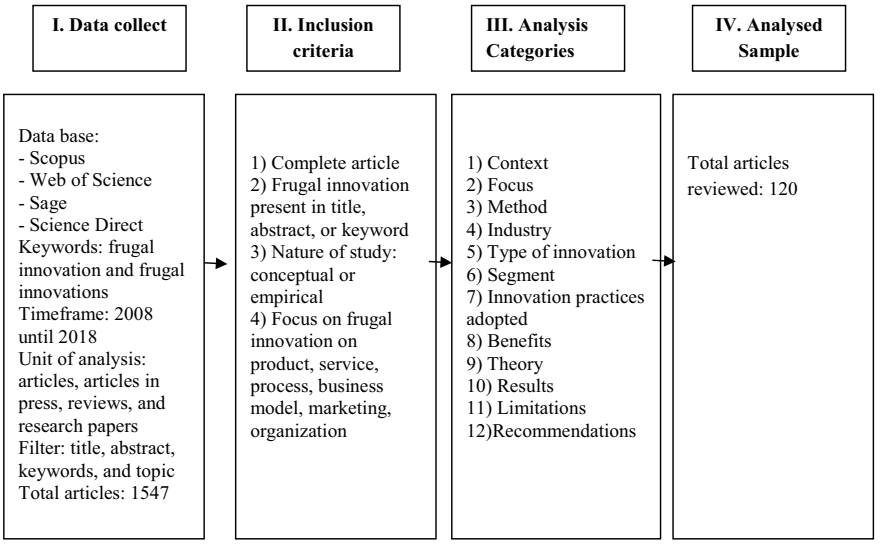

Fig. 17.1 Research design

Table 17.1 Classification meaning codes for alternatives

Ranking	Meaning	Codes for alternatives
1	Context	A—Developed country B—Underdeveloped country C—Comparison between countries D—Not applicable
2	Focus	A—Only frugal innovation B—Frugal innovation and other innovation practices C—Frugal innovation and other management practices D—Frugal innovation is not predominant in the analysis
3	Method	A—Quantitative B—Qualitative C—Conceptual D—Quantitative/qualitative or qualitative/quantitative E—Experiment F—Cases
4	Activities	A—Manufacturing/Industry B—Services C—Other: which D—Not applicable
5	Type of innovation	A—Product Innovation B—Innovation in services C—Process Innovation D—Marketing Innovation E—Organizational innovation F—Business model innovation G—Not applicable
6	Sectors	A—Primary: involves the extraction and/or production of raw materials, such as corn, coal, wood, or iron. Examples of primary sector workers may be a coal miner and a fisherman B—Secondary: involves the transformation of raw materials into goods, such as the manufacture of steel for cars or textiles for clothing. Examples of secondary sector workers may be a civil builder and a couturier C—Tertiary: involves the provision of services to consumers and/or companies, such as babysitting, cinema, or banking. Examples of workers in the tertiary sector may be a shopkeeper and an accountant D—Not applicable

(continued)

Table 17.1 (continued)

Ranking	Meaning	Codes for alternatives
7	Innovation practices adopted	A—Organizational and planning practices B—Operational Practices C—Communication practices D—Other: which E—Not applicable
8	Benefits of frugal innovation	A—Top management B—Other employees C—Other stakeholders D—Other, what E—Do not quote in the study
9	Theory or conceptual approach used in the study	Mention in this field what theory or conceptual approach was used to develop the study
10	Main outcome of the study	Present here the answer to the objective of the study
11	Limitations of the study	Present the research limitations

In Stage III we use the categories of frugal innovation analysis described by Weyrauch and Herstatt (2016) to evaluate the type of innovation mapped in the articles analyzed.

Figure 17.1 shows the steps that were followed to conduct the study.

Then, Table 17.2 presents the most representative journals which published the studies that were analyzed.

Presentation, Analysis, and Discussion of Results

Figure 17.2 presents an overview of the main research results.

Figure 17.2 shows that 44.72% of the studies analyzed were conducted on emerging countries and another 7.32% of the studies did a comparison between countries. This signals that frugal innovation tends to be studied more intensely in underdeveloped countries. The populations in underdeveloped countries represent the more common users who benefit from the technologies, products, infrastructure, and processes derived from frugal innovation. On the other hand, Weyrauch and Herstatt (2016) have pointed out that frugal innovations have also penetrated developed countries and are often referred to as reverse innovations.

Furthermore, 71.66% of the studies approached frugal innovation as the main analysis objective or associated it with management or innovation practices. This shows that there is an emphasis on conceptual and empirical writings that explore frugal innovation in depth. Frugal innovation provides for the redesign of output, production processes, and the business model (*The Economist*, 2010), which creates a new context for innovation that values social attributes, individual competencies,

Table 17.2 Periodicals that published the analysed studies

Journal	Total	Impact factor
Journal of Cleaner Production	8	5651
The European Journal of Development Research	8	1323
Procedia CIRP	6	0
Technological Forecasting & Social Change	5	3129
Technology in Society	5	0
Journal of Indian Business Research	4	0
Sustainability	4	2075
Technovation	4	4802
European Journal of Development Research	3	1323
Research-Technology Management	3	1796
BMJ Innovations	2	23,295
Environmental Innovation and Societal Transitions	2	5265
Globalization and Health	2	3031
Health Affairs	2	5.23
IEEE Engineering Management Review	2	1.94
International Journal of Innovation Science	2	0
Journal of Innovation Economics & Management	2	0
Journal of International Management	2	3.85
Long Range Planning	2	3221
Procedia Manufacturing	2	0
Research Policy	2	4661
Technology Innovation Management Review	2	0
Outros	46	
Total	120	

and group experiences to stimulate co-production and to contribute to the innovation ecosystem. The co-production process brings the local entrepreneur closer to the end user, thereby reducing costs typically borne by users (Wehn and Montalvo 2018). Above all, the process highlights the attributes of frugal innovation, which are significantly lower manufacturing costs, ease of use, limited resources, and low impact on the environment (Weyrauch and Herstatt 2016).

Methodologically, there was a predominance of qualitative studies, followed by conceptual studies, corresponding to 29.75% and 23.97%, respectively. This shows that the frugal innovation theme is still in an embryonic stage. Exploratory, qualitative and case studies tend to be characteristic of emerging research themes. Conversely, conceptual studies typically seek to understand and problematize the theory, inspiring the validation of research propositions. A mature topic tends to consolidate articles that present models of analysis, surveys, and structured statistical analyses.

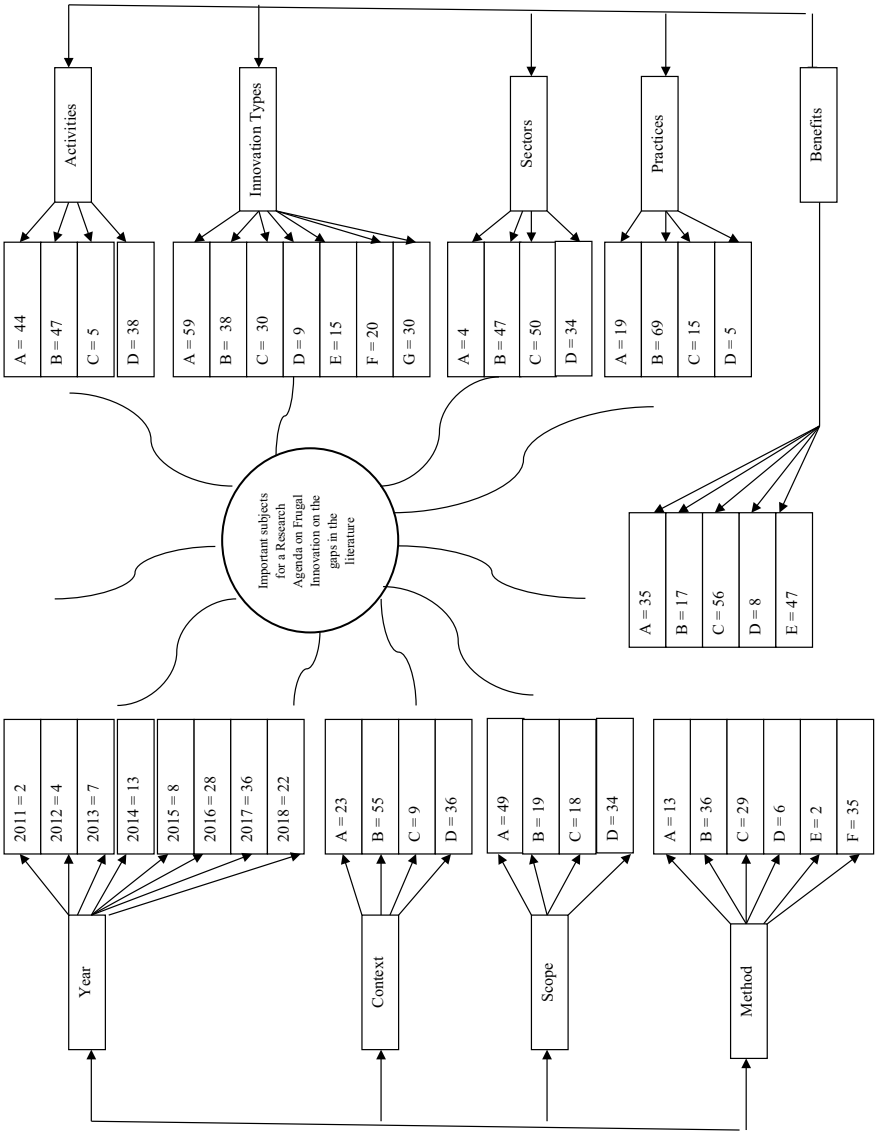

Fig. 17.2 Main results

Regarding the sectors surveyed, there was a predominance of the services segment, followed by manufacturing/industry, with shares of 35.07% and 32.84%, respectively. Subsequently, 29.35% of the studies focused on product innovation and 18.91% on service innovation. Regarding the innovation practices adopted, it is evident that operational ones (46.62%) were the practices most frequently highlighted, followed by the planning of organizations (12.84%). This evidence correlates with the study of Tiwari et al. (2014), who point out that frugal innovation tries to minimize the use of material and financial resources in the various stages of the value chain. This reduces the initial acquisition cost and the total cost of the product, including usage and maintenance, and hence requires less of society's natural and financial resources. The result is to make available products that are inclusive and suitable for people in situations of social vulnerability. Product service systems are alternatives that provide access to the product (Tukker 2015), without blocking ownership, and can be efficient alternatives for emerging countries to invest into meet their basic needs in health, education, infrastructure and the environment.

With regard to the benefits of frugal innovation, 34.36% of the respondents had different levels of attention, and 21.47% of the studies indicated that frugal innovation benefits top management. Such evidence is in accord with the frugal innovation criteria defined by Weyrauch and Herstatt (2016): substantial cost reduction, concentration on basic functionalities, and optimized performance level. The analysis also links to another emerging theme, sustainable development, as provided in the study of Rosca et al. (2018).

The use of theory in studies dealing with frugal innovation is an opportunity for further exploration. Only one study explored the resource-based view, and another study indicated that it used the Theory of Innovation Diffusion. All others focused on diverse and superficial theoretical aspects, which makes it difficult to promote advances in the construction of theory, to test theory in the cases analyzed, or to validate empirical data in light of theory. None of these approaches can build a consistent conceptual paper. Above all, as Rao (2013) emphasizes, the adoption of frugality implies design principles that advocate the minimum use of resources to achieve efficient functioning of products.

Discussion of the Results

Frugal innovation plays an important role in democratizing access to goods and services, especially for the most vulnerable populations (Jha and Krishnan 2013). The simple, labor-intensive, scale-specific technologies directed (Winnink et al. 2018) to the target audience of low-income consumers bring relief to people living in extreme poverty (Kaplinsky 2011). They provide solutions in remote sites that cannot be achieved by regular local government initiatives (Prabhu and Jain 2015). In terms of meeting the goals of sustainable development, frugal innovations provide developing communities with the possibility of purchasing products that suit their needs and their purchasing conditions (Rosca et al. 2018). These are products that have been

developed and formulated with a view to reducing the use of natural resources and allowing the creation of inclusive economic growth (Knorringa et al. 2016), and further, to contributing to the motivations, challenges, and opportunities of successful problem solvers participating in virtual teams of innovation contests (Hossain 2018).

For entrepreneurs, frugal innovations provide the opportunity for business profits that serve a specific niche; these consumers are thirsty for innovations and products that are accessible to their income condition (Tata and Matten 2016). However, there are scholars who are critical of frugal innovations, especially since they do not address the problem of poverty. As Nahi (2016) says, the provision of affordable products and services does not solve the structural roots of poverty. On the other hand, scholars do recommend palliative solutions that contribute to the improvement of people's living conditions, despite being unable to solve the social asymmetries that exist in society. In a way, frugal innovation is a low-cost survival strategy (Pansera and Owen 2015).

Frugal innovations comprise technologies popularized by non-governmental organizations and by development agencies (Rosca et al. 2018). There are several solutions for health care sectors, which seek to provide access to treatment and minimum care. This sector is cited in Wehn and Montalvo's editorial (2018) that deals with innovations of water. The energy segment also benefits from frugal innovations by providing alternatives that make use of renewable energies and require low maintenance, including solar, wind, and biogas (Nocera 2012). Co-design and co-production of frugal innovations enable local small-scale entrepreneurs to customize their offerings. They can consider the designation of origin, proximity of production and place of consumption, along with factors related to local beliefs, traditions, cultures, and habits. For Weyrauch and Herstatt (2016), frugal innovation has the potential to reduce costs, concentrate on basic functionalities, and optimize performance.

Nevertheless, there are criticisms of frugal innovation's level of contribution towards sustainable development. Rosca et al. emphasize that using fewer natural resources is not synonymous with environmental protection (2018). Still, the benefits of frugal innovation appear more significant. Those benefits include: increased inclusion of people in the labor market, a boost in entrepreneurship and local capacity building, reduced inequalities, protection through an approach of efficiency and sufficiency, the generation of solutions based on the local dynamics, access to the considered community's resources with frugal innovation, access to scarce products and services for poor people, and contributions to people's motivation and well-being.

Frugal innovation can generate development, considering the different actors in the private sector (Rosca et al. 2018). However, frugal products, services, and systems do not address the root of the poverty problem; this factor is considered a huge flaw of this type of product. Products that have a focus on functionality and a radically reduced cost structure offer certain advantages; they offer a value proposition that incorporates a reduction of the total price of property, and they offer robustness, ease of use, and economies of scale (Tiwari et al. 2014). Moreover, frugal innovation creates an interesting pathway to internal innovation activities while working with limited resources to manage such open innovation processes (Radziwon and Bogers, 2018). The overarching goal is to generate and ensure an effective adoption of innovations that address the needs of the underserved (Ramani et al. 2017).

Final Remarks

This study examines scientific publications on frugal innovation in terms of their context, focus, sector in which they are operationalized, method adopted, innovation practices, benefits, and contributions to society. Evidence shows that this issue has been expanding in the last three years, corresponding to 71.66% of the period's publications. It is a subject explored as an object of analysis in emerging countries, with an emphasis on studies developed in India. Predominantly qualitative and conceptual studies were done. This shows the potential of the area for advances in meta-analyses, surveys, experiments, ethnographies, phenomenologies, comparative studies among countries, and so forth. Moreover, the type of technology and the infrastructure resources derived from frugal innovation and societal benefits are elements that need further academic exploration.

The implications of this research are directly associated with the scientific advances of the subject. There is potential for comparative studies between emerging and developed countries. There is an opportunity to proceed with longitudinal studies, mapping a database of frugal innovations per continent, in order to identify the different types of technology, scientific expertise, and social benefit that the mapped innovations can bring to the communities in which they are targeted. A categorization that identifies the social, economic, and environmental benefits of frugal innovation is relevant, since communities in situations of social vulnerability tend to have different fragilities. A category that measures benefits to health, food, well-being/leisure, and/or labor/work can include elements not mapped in previous studies.

As a limitation of the research, we assume the restricted scope of investigation mapping. We used only the term frugal innovation. Future studies may investigate in depth the nature of frugal innovation in associated mindsets (such as jugaad, bricolage, effect, improvement, Gandhian innovation, inclusive innovation), process (frugal engineering and Lean), and outcome (appropriate technology, disruptive innovation, bottom of pyramid innovation, and reverse innovation).

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