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A Resource-Based View on Frugal Innovations: Frugality-based Advantage to Enable Sustainable Entrepreneurial Impact

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Abstract. Frugal Innovation (FI) within small and medium-sized enterprises (SMEs) has the potential to drive sustainable and financial value in resource-constrained environments. Grounded in Resource-Based View (RBV) assumptions that firms can strategically leverage limited resources for competitive advantage, this study adopts a meta-synthesis methodology, systematically analysing FI case studies to evaluate frugality-based advantage (FBA) across four main constraints: input, income, infrastructure, and resource overuse. The findings reveal that 65% of the FIs examined achieved sustained competitive advantage and positively impacted the Sustainable Development Goals. This suggests that FI is a valuable strategy for SMEs facing severe resource limitations, offering actionable insights into sustainable development for vulnerable SMEs. Our study results in an adapted Value, Rare, Imitable, Non-substitutable (VRIN) framework used to assess the effectiveness of FIs in sustaining competitive advantages that have a sustainability impact.

Keywords: Frugal Innovation; SMEs; Resource-based view; Sustainable Development Goals.

> "Frugal Innovation is the alchemy that turns distress into opportunity" – Radjou et al. (2012)

1. Introduction

Frugal Innovation (FI) has emerged as a powerful approach to address critical global challenges, particularly resource constraints faced by businesses and

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society at large (Radjou and Prabhu, 2015; Prabhu & Jain, 2015; Le Bas, 2023b). Defined by its focus on achieving more with less, through minimal resource use while maximising utility and lifecycle value, FI offers a transformative pathway for businesses to innovate amidst adversity (De Marchi et al., 2022; Le Bas, 2023b). As a vehicle for sustainability, innovations have the potential to align business practices with the Sustainable Development Goals (SDGs), simultaneously promoting economic, social, and environmental progress, often referred to as the triple bottom line (Elkington, 1998).

Small and Medium-sized Enterprises (SMEs) face intensified resource constraints due to economic turbulence from global crises, exacerbating their inherent vulnerabilities (Bertello et al., 2022; Hampton et al., 2023; Clauss et al., 2022). Further, the liability of smallness (Freeman et al., 1983) that SMEs generally face means that SMEs are "more vulnerable to internal and external events" (Eggers, 2020, p. 199). When the scarcity of resources for SMEs is severe enough, it may be considered a crisis. To survive, businesses must build resilience, which is the capability to sustain (or optimise) a value proposition under dynamic and unpredictable circumstances (Radic et al., 2022). SMEs continuously need to secure their future, which can be done through "innovate[ing] their products, processes, and business models" (Bertello et al., 2022, p. 90; Adam & Alarifi, 2021).

A second crisis involves the depletion of Earth's finite resources and the means by which we have collected them, such as fossil fuels and minerals, has had immense social and environmental repercussions (IPCC, 2022). Moreover, the resources are distributed unevenly, further stratifying the global southern and northern regions. Frugal Innovation (FI) can serve as a potential solution to many of these issues (Le Bas, 2023b; De Marchi et al., 2022). In this study, when sustainability impact is referred to, it is not meant to encompass firm sustainability or longevity, but instead an impact on shifting to a more sustainable and circular society. We discern this impact through the Sustainable Development Goals, which include social, economic, and environmental attributes (Le Bas, 2023b).

At the epicentre of these two intertwined crises, i.e. resource scarcity for SMEs and societal sustainability, lie the ways in which resources are used, collected, and distributed, and the value generated with them (Leliveld & Knorringa, 2018). SMEs have the opportunity to not only create (financial) value for customers, but also to create value for the Planet and the People on it (Planet and People). Although larger companies also have a profound impact on sustainability goals, SMEs were selected as the focus of this study for the two primary contexts outlined above. First, the many crises facing us pose a significant threat to vulnerable SMEs, which "are more fragile in times of crisis" (Durst et al., 2022, p. 1). Ensuring that this threat is mitigated is essential, as SMEs are of profound importance to the economy, comprising 90% of the global economy, and over 50% of employment comes from formal SMEs (World Bank, 2019). Second, SMEs have a profound impact on planetary health; for instance,

they contribute a staggering 60-70% of industrial pollution (OECD, 2019). Thus, it is essential to explore how to resolve their impact on the planet in terms of environmental capacity without negating their important economic contribution. FI provides a framework for SMEs to navigate through these challenges by turning resource constraints into opportunities. This study focuses on how SMEs use FIs to deal with severe resource constraints and build a resilient business model. To investigate this, we develop and analyse a unique dataset of FI case studies from SMEs worldwide. By combining a meta-synthesis of case studies with quantitative content analysis, we provide insights into the theoretical evolution of FI, its relationship with SMEs, and its potential to address resource scarcity.

This study examines FI's theoretical evolution and its role in addressing resource scarcity through the opportunity to create a frugality-based advantage (FBA) for SMEs. FBA is defined as the "advantage that a firm has over competitors in its ability to develop and use frugal innovations, that is, innovations that overcome external resource constraints" (Asakawa et al., 2019, p. 2). This study provides an understanding of how an FI innovation framework can render value. The theoretical exploration ends with a predicted conceptual framework of how this can generate multiple types of values. In this way, we contribute to the operationalisation of the FBA as a concept and provide a link between sustainability and FI for entrepreneurs. The core of this framework and study explores the conditions under which FI can create FBA and generate multiple values (value for society through the impact of the SDGs, financial value for SMEs and value for customers). We aim to understand this through the method of collating a meta-synthesis of FI case studies, which we analyse using quantitative content analysis to test our conceptual framework. Ultimately, culminating in an answer to and discussion of our research question: *What are the approaches and conditions for small businesses to create multiple values from resource constraints?*

2. Theoretical Foundation

2.1. Frugal Innovation

The underlying concept used in this study to alleviate the aforementioned resource constraints is Frugal Innovation (FI). The theoretical concept of FI is to achieve more value while using fewer resources (Bhatti, 2012; Dabić et al., 2022). This concept emerged from resource-constrained settings, historically connotated as developing nations or the so-called bottom of the pyramid, where resource scarcity necessitates a certain type of innovation (Dabić et al., 2022; Hossain, 2018; Prabhu, 2017). In the last decade, the concept of FI has been developed using a multitude of approaches. Hossain (2018) highlighted the value of the framework for operating outside the sphere of emerging economies, furthering its

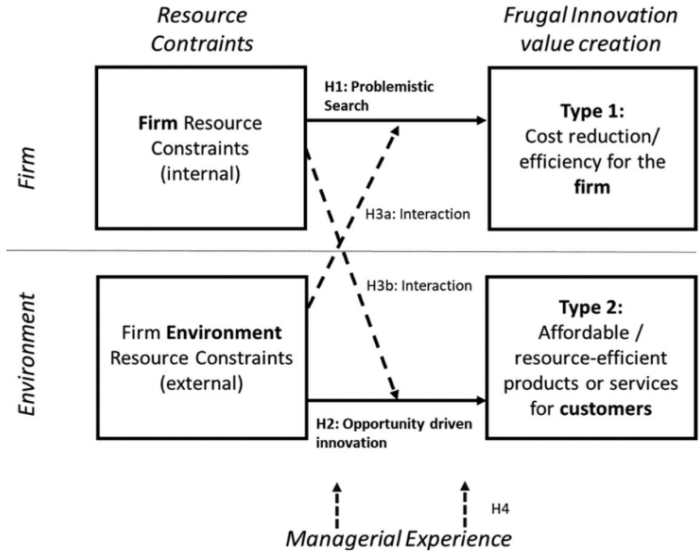
applicability in business. Frugal innovations are specifically designed for resource-constrained environments, which are often found in the Global South. However, there is an increased demand for research on frugal innovations in the Global North (Leliveld & Knorringa, 2018). Weyrauch and Herstatt (2016, p. 2) determined three core characteristics of FI: "substantial cost reduction, concentration on core functionalities, and optimised performance level." Radjou and Prabhu (2015) popularized the term FI, highlighting it as the process of creating more value with fewer resources. It emphasises the achievement of significant outcomes by leveraging minimal resources, often through ingenuity, adaptability, and efficiency. It has gained popularity among scholars and practitioners as a potential key to many challenges faced globally, such as resource depletion and sustainability-related challenges, including climate change (Leliveld & Knorringa, 2018; Prabhu, 2017; Chakravarty & Gómez, 2024). FI provides an opportunity for social agency or sustainability for SMEs, which ultimately leads to the creation of value for the planet and the people living on it.

2.2. Taxonomy of Frugal Innovations

Frugal innovations can be classified into several taxonomies. Building on Ploeg et al. (2021) and Hossain (2018), we classify FIs into two distinct categories. First, frugal innovations emerging from firms' internal resource (or organizational) constraints; such FIs typically occur as process innovation, and are often overlooked as a category of frugal innovation (Ploeg et al., 2021). FIs stemming from internal constraints are, for example, overcoming substantial transportation limitations or limited R&D resources. Second, FIs arising from external constraints (firm environmental resource constraints) such as FIs overcoming the (in)ability of customers to offer upfront investments in a product.

Ploeg et al. (2021) hypothesise a model which leads to value creation based on these two forms of FIs for firms and how they create two types of value for consumers and firms (see Figure 1). We add to this taxonomy by identifying another type of value, namely value for society that can emerge from both the internal and external classifications of FI.

Figure 1: Reprinted from Ploeg et al. (2021)



2.3. FI Value Creation

Hossain (2018) highlights that resource-efficient innovations can address social and environmental challenges, making FI a viable sustainability strategy. Achtelik et al. (2022) highlights the link between FI and sustainability. Le Bas (2023a, p. 74) further reiterates this and points to FI as "an enabler of the goals of sustainability". Nonetheless, he highlights that this may not always be the case; therefore, it is important to classify the level of sustainability of an FI. As such, Le Bas introduced (2023a, p. 74) a taxonomy that distinguishes between "fully sustainable" and "weakly sustainable" FIs. Fully sustainable FIs align comprehensively with environmental and social objectives, whereas "weakly sustainable" ones may offer cost reductions and resource efficiency but fall short in broader sustainability impacts. These variables can be integrated into the value creation attributes of Ploeg et al. (2021)'s model.

FI has the potential to be part of a solution to a resource crisis (Albert, 2022; De Marchi et al., 2022; Eggers, 2020), however, there are criticisms of the concept that need to be addressed to proceed with it. Two important critiques are the lack of a theoretical foundation and the insufficient empirical link between the sustainability effect of FI. Although Le Bas (2023a) creates this empirical link, he highlights that "future researchers need to ... improve the empirical work on the complex relationship between frugality and sustainability" (p. 87).

2.4. FI in the Resource-Based View

There are criticisms of FI as a theoretical lens, the first and foremost being its lack of theoretical underpinnings (Bhatti, 2012; Harris et al., 2020; Dabić et al., 2022; Sarkar & Mateus, 2022; Le Bas, 2023a). Dabić et al. (2022) highlight that "the

majority of frugal innovation research is focused on its technology and innovation aspects, with limited context-specific theory and development" (p. 926). Dabić et al. (2022) began tackling this issue and outlined the applicability of several theoretical foundations to better understand FI. The fragmented research on FI and its steady growth makes it more difficult to generate an underlying theoretical foundation that supports a multitude of research directions. Dabić et al. (2022) outline several possible theoretical avenues that could be explored to build a stronger basis for FI theorizing: Network institutional theory, Transaction cost economies, Innovation theory, and the Resource-based view. Lim and Fujimoto (2019) emphasise that FI is especially relevant for SMEs, which may lack resources for high-tech solutions but can leverage cost-effective, simplified designs with reduced technological complexity to create financial value. These insights reinforce the notion that technological frugality not only addresses internal resource constraints but also enhances a firm's ability to innovate effectively within constrained environments. For this study, the resource-based view was selected, as it best facilitates an understanding of how SMEs can leverage their resource constraints to create value and a competitive advantage (Dabić et al., 2022; Shibin et al., 2018). Thus, it provides a different perspective on the academic discourse that focuses on FI, particularly when understanding how SMEs can achieve multiple values through FI.

Further, the resource-based view is utilised to understand why firms grow and diversify (Barney, 1991; Lowe & Teece, 2001). This theory originates from Penrose (1959), who identifies the catalysts of growth as unused managerial resources. RBV takes the perspective that all firms are "bundles of resources" that "enable the creation of economic value" (Barney et al., 2021, p. 1942). Furthermore, to garner a better understanding of the resource constraints faced by firms, the RBV provides a substantial means of understanding competitive advantage (Barney, 1991). The RBV supports FI in several ways. Both approaches emphasise the importance of understanding and managing a firm's resources (Asakawa et al., 2019; López-Sánchez and Santos-Vijande, 2022). Going beyond cost resources and examining knowledge, staff, social embeddedness, and other pressures as resources, RBV highlights the importance of dynamic capabilities. These are essential for SMEs to adapt to and respond to the changing market conditions and customer needs, which are essential for value creation and resilience building (Hossain et al., 2022; López-Sánchez & Santos-Vijande, 2022). As the landscape formed by these severe resource constraints forces SMEs to actively innovate their business models towards sustainability and resilience (Ozanne et al., 2022), RBV presents a framework for FI to be utilised as an opportune solution. Thus, it can be concluded that the RBV presents a strong theoretical underpinning for FI.

One RBV concept that can determine competitive advantage is the VRIN framework (Porter, 1996; Barney, 1991). This framework includes different types of conditions that determine the availability of crucial resources that create a

strategic advantage for the firm. The first two letters pertain to the presence of a resource that creates a substantial advantage (Value & Rare). The second two factors show how long that advantage can be maintained (is the innovation imitable and non-substitutable). However, no timeframe has been established for how long this advantage must be maintained to be considered fulfilled. Barney et al. (2021) recently elaborated on this in a response paper on the RBV. They address this limitation by considering the value-creation framework, highlighting that sustaining an advantage is achieved by continually leveraging firms' resources and capabilities (Barney et al., 2021). However, they do not outline *how* firms can leverage them.

3. Conceptual Foundations

3.1. Frugality-Based Advantage

As an extension of the resource-based view of the firm, Asakawa et al. (2019) argue that leveraging resource constraints can provide a competitive advantage, which they call the Frugality-Based Advantage (FBA). A frugality-based advantage is the advantage a firm achieves over its competitors in its ability to develop and use frugal innovation. In other words, innovations that overcome severe external resource constraints are needed to develop business models that provide entrepreneurs with agency and value; for example, historically, the financial constraints of the bottom of the pyramid consumers. The concept of FBA diverges from traditional strategic management approaches, such as cost leadership and differentiation, as proposed by Porter (1996). Unlike conventional strategies, the frugality-based advantage amalgamates the elements of both, and is not limited to cost reduction. It also involves redesigning products and services to achieve optimal performance while preserving core functionalities.

Asakawa et al. (2019) highlight the potential advantage of a resource constraint, as opposed to the resource itself being the advantage. For an SME to gain a frugality-based advantage, there must be a substantial and sustainable competitive advantage over others. To outline this, Asakawa et al. (2019) built on the original VRIN framework of the RBV (Porter, 1996; Barney, 1991). Asakawa et al. (2019) outline three types of severe resource constraints that, through FBA, present an opportunity for SMEs: input, income and infrastructure. An input crisis outlines a lack of resource inputs for the production process. An income crisis occurs when the Business Model (BM) space in which an SME operates has customers with limited income. Thus, to be viable, businesses must be able to lower their price points. This relates to Kumar's (2020) positioning of entrepreneurs that find opportunity in inherent paradoxes; the income shift is one way to do this and be able to maintain the balance of Triple-Bottom Line (3BL) value creation. Infrastructure-based resource constraints are contexts where businesses operate in a space with infrastructural limitations, these crises often

occur in Bottom of Pyramid contexts. These three severe resource constraints can lead to frugality-based advantages.

In the developed context, there is a fourth type of crisis of resource overuse. Niessen and Bocken (2021) indicate that this can be viewed through the lens of sufficiency. Sufficiency-based business models are centred on sustainable consumption, aiming to incentivise consumers to use less by introducing substitute products or services that shift the value proposition, making sufficiency the preferred option for consumers (Bocken et al., 2022). This fourth addition can be further supported through paradox theory, which highlights the inherent opportunity of how the 3BL of economic and sustainability value is pursued in the paradoxical context of using too many resources and thereby frugally innovating. These models are designed to promote the use of fewer resources, not because of income, but because of consumers' willingness to use fewer resources (Niessen et al., 2023). Thus, further impacts can be generated to enable sustainability. Asakawa et al. (2019) indicate that research on FBA should be continued to gain a refined understanding of the concept and critically study how businesses utilize it and the impact that it generates. As such, this research will contribute to the refinement of FBA as a means for SMEs operating in times of resource crisis to use the crisis as an opportunity to build balanced and impact-generating business models. Furthermore, by connecting it to paradox theory in understanding that FI and sufficiency is a paradox that "provide[s] opportunities for entrepreneurs to act in novel ways that engage and embrace complexities and contradictions" (Kumar, 2020, p. 497). This 3BL value creation in the context of FI can be understood by analysing FBAs' conditions in case studies of FI emerging from severe resource constraints.

3.2. Sustainability Value Creation by Frugal Innovations

It is argued that FI can address two issues simultaneously, being able to not only alleviate the exacerbating resource constraints SMEs currently feel, but also contribute to solving the global sustainability crisis (Albert, 2019; Hampton et al., 2023). Kumar (2020) presents this as the 3BL of value creation. One criticism is the need to strengthen the understanding of how FI can contribute to or be linked with sustainability research. Hossain (2021, p. 2) emphasizes that there is a "lack of knowledge about how FI contributes towards sustainability." There is an assumption in the literature that FI leads to more sustainable outcomes, which is derived from the fact that it uses fewer resources. Promoting sustainability within FI is still a "relatively new nature of a research domain that requires further studies" (López-Sánchez & Santos-Vijande, 2022, p. 191; Albert, 2022). De Marchi et al. (2022) postulate that more empirical evidence is needed to gain a true understanding of the impact FI could have on sustainable development. This is further established by Rosca et al. (2017) and Albert (2022, p. 2), who reiterate the need for a "sufficient base of empirical evidence of economic, social, and ecological impacts of frugal innovations on sustainable development". Le Bas

(2023a) recently addressed these criticisms by creating an empirical model for FIs that provides a taxonomy of FIs categorising them as Fully sustainable FIs and Weakly sustainable FIs. He further stipulates that FIs are predominantly inherently sustainable, however not all of them and certainly not the primary focus, in fact it is "often a side-effect rather than an upfront impulse" (p. 80). Nonetheless, Le Bas found that a literary review of FI case studies revealed a majority to be fully sustainable FIs, indicating an empirical link between FI and sustainability. We aim to add to this discussion by further exploring the conditions that lead to FIs that fall into the latter category of creating sustainable value, and what form of sustainable value they create.

Dabić et al. (2022) highlighted the issue of an all-encompassing ability to assess FI, and its sustainability impact is critical for advancing this field (see also Albert, 2022). However, sustainability is generally difficult to measure, particularly for practitioners and SMEs that lack specific knowledge. As such, a conceptualised form of empirical measurement that can be utilised to 'frugally' assess sustainability impact is needed. Despite its importance, there remains a pervasive research gap. We aim to contribute by demonstrating that FBA in SMEs can present an assessable sustainability impact and which form it takes through the lens of SDGs.

3.3. Conceptual Framework

We build on Ploeg et al.'s (2021) taxonomy of FI and its value creation, by connecting Asakawa's frugality-based advantage and offering a further type of added value than Ploeg's original model. Ploeg originally defined two types of values that emerge from FIs. One is for the firm, and the other for the customer (see Figure 1). We expand on this by adding a third type of value, namely, the value for society. Firm resource constraints are further delineated as those arising from input and income constraints. For firm environmental resource constraints, we define infrastructure- and sufficiency-based FBAs. From this, an adapted conceptual model emerges to answer how we can create multiple forms of value based on the taxonomy of FIs in firms. We take two approaches to address value creation that respond to severe resource constraints: one considers FBA, and the other considers SDGs. One approach aims to understand the FBA side of value creation (for SMEs), and the other one considers the SDG side (for society). Ultimately, as the issues are intertwined under severe resource constraints, the solution needs to consider both sides of the sustained value that we are trying to achieve. Using these approaches, we determined the conditions for testing. There are four predicted VRIN conditions for an FI to become an FBA, thereby creating a financial advantage for an SME. Moreover, there are two conditions for the SDG approach, which have a measurable impact on the SDG delta, as described below. A measurable SDG delta impact, in turn, creates societal value. Through these combined approaches to resource constraints, we predict that multiple value creations can be achieved for both society and small businesses.

The VRIN conditions were informed by the original VRIN attributes (described above) as well as by Asakawa et al. (2019). The adapted attributes are as follows: Valuable (V) - The frugal innovation helps to overcome a resource constraint that creates value for the customer; Rare (R) - Does the FI focus on getting around the lack of availability of a particular Rare input and finding new ways of substituting its use; Imitable (I) - other firms cannot easily copy it because of the unique historical context, causal ambiguity, and social complexity; Non-substitutable (N) - Competitors find it difficult to solve the constraint with other innovations. Although it is unlikely that all attributes are simultaneously achieved, it is argued that some levels of these conditions must be met to form an FBA.

The second approach determines the conditions for Frugal Innovation to create sustainability value. The framework of Sustainable Development Goals (SDGs) has been used in previous studies to assess the sustainability impact of Frugal Innovations (Dressler & Bucher, 2018; Levänen et al., 2016). Building on this, we assign the SDG delta (change) as an indicator of sustainability impact. The delta SDG (Kraaij et al., 2023) is a metric used to determine the presence of an inclusive sustainability impact. This is predicated on the notion that there is a sustainability impact if there is a positive environmental or social change in society, which is achieved if one or more of the SDGs are positively impacted (Kraaij et al., 2023). Assuming the presence of a positive delta, we can then extrapolate using practical SME case studies, in which the SDGs are impacted by the FBA.

Having an established metric to test, as well as two clear research gaps for FI, we arrived at a conceptual framework of conditions for multiple value creation (see Figure 2) and aimed to test this framework from qualitative case studies found in FI literature. As such the questions we want to explore are as follows:

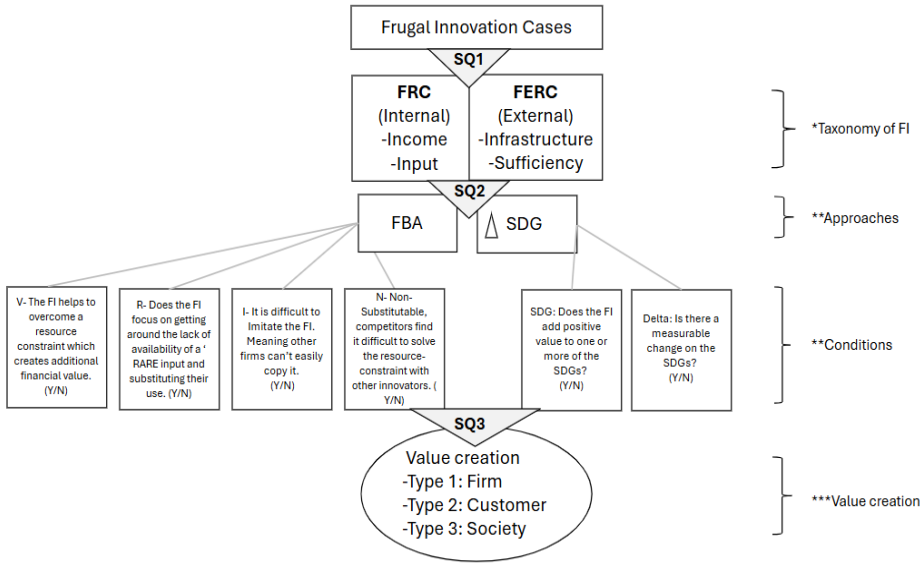
Main Research Question: What are the approaches and conditions for small businesses to create multiple values from resource constraints?

Subquestion 1. How can FIs be classified? *

Subquestion 2. What are the approaches and conditions that can be used to determine multiple value creation? **

Subquestion 3. What types of value creation emerge from these approaches and conditions? ***

Figure 2. Conceptual framework



Note: SQ =Sub-Question; FRC = Firm Resource Constraints; FERC = Firm Environment Resource Constraints; FBA = Frugality Based Advantages; SDG = Sustainable Development Goals; FI = Frugal Innovations.

4. Research Approach and Design

To answer our research question – *What are the approaches and conditions for small businesses to create multiple values from resource constraints?* – we compiled case studies of FIs by SMEs from existing literature. We then analysed this large dataset of cases using quantitative content analysis (QCA) to test the determined conditions. The methodology is outlined in the following section.

4.1. Meta-synthesis

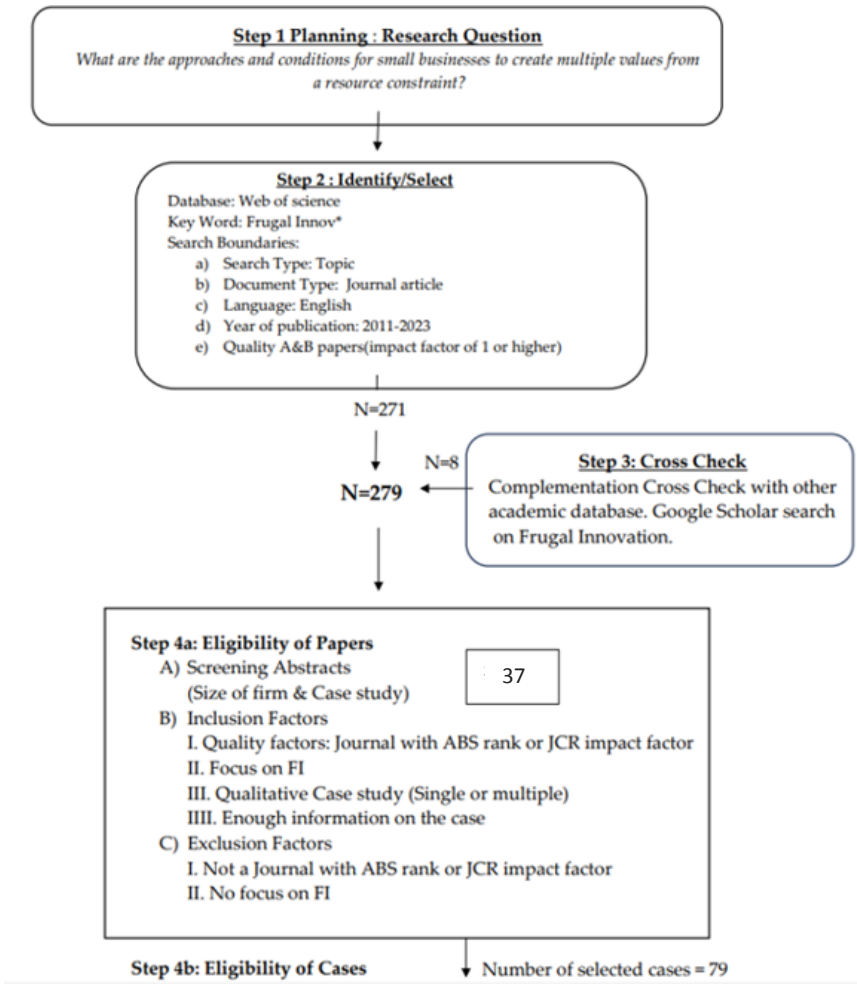
As several literature reviews exist on FI (Agarwal et al., 2017; De Marchi et al., 2022; Hossain, 2018; Hossain et al., 2016; Pisoni et al., 2018), a meta-synthesis is ideal for drawing new conclusions from multiple studies. It is well suited for qualitative case studies and quantitative content analyses. As FI research is overwhelmingly qualitative (Sarkar & Mateus, 2022), meta-synthesis is well-suited. This method allows for the aggregation of independent results to obtain a more precise estimate of the effects of an intervention or response. Hoon (2013) laid out eight steps for creating a meta-synthesis of the literature that we followed. These steps are explained in the Appendix (Section B). For meta-synthesis to be a rigorous methodology, the selection of relevant literature must be meticulous in order to provide valuable results (Sarkar and Mateus, 2022). The subsequent section explains the selection process followed to discern the literature.

4.2. Search Method and Selection Procedure

This study uses a stepwise method informed by Asakawa et al. (2019) and their PRISMA selection, as well as Sarkar and Mateus (2022), and their application in selecting the literature for meta-synthesis. This selection method was chosen to provide a rigid and replicable dataset of innovations, as it applies well to meta-synthesis. An adapted model that integrates these two rigid frameworks is shown in Figure 3, illustrating the literature selection procedure. The following section outlines the criteria for our systematic search, providing clear exclusion and inclusion criteria to ensure that only quality papers that presented case studies of Frugal Innovations were selected.

The first step in literature selection was to identify the boundaries of our initial search. The boundaries selected for our literature collation were peer-reviewed searches in the Web of Science database under the topic of Frugal Innovation. We further refined the parameters by searching for English journal articles published from 2011 (when the term began to become popular in the literature) until the first half of 2023. The initial search parameters generated 271 results. To ensure rigidity, the same search variables were used on Google Scholar. This yielded an additional eight articles. The next attribute of the selection criteria in a meta-synthesis, according to the logic of both Hoon (2013) and Sarkar and Mateus (2022), needs to include a broad range of cases, yet be refined enough to be a manageable dataset. Thus, the literature sample was further screened by reading the abstracts to determine which articles were included in the analysis. When screening abstracts, the first criterion for selection was that the article contained at least one case study of FI executed by an SME. Sarkar and Mateus (2022) further emphasised the need for clear inclusion and exclusion criteria. According to Grégoire and Cherchem (2020), the first attribute is required to determine the quality. As such, to ensure quality, we added the inclusion criteria of only selecting articles that were peer-reviewed in the ABS Guide or indexed in the JCR with an impact factor of one or higher. The next variable in our exclusion criteria was weeding out any articles that did not focus on FI. As per Carlson and Palmer (2016) and Hoon (2013), a meta-synthesis must ensure that qualitative case studies are used. Thus, we excluded any papers that did not present any case studies. Lastly, according to Hoon (2013), cases should also provide clear and sufficient empirical information for authors to interpret. Therefore, in our final exclusion criteria, any case study that did not provide enough empirical information about the cases they described were not included. This resulted in a final set of 37 articles that were included in our meta-synthesis. Some articles described several case studies with sufficient empirical information and we collated all case studies that fit the same criteria, including 79 case studies. The selection procedure is shown in Figure 3, followed by the analysis method.

Figure 3. Stepwise Methodology adapted from Asakawa et al. (2019) and Sarkar & Mateus (2022).



4.3. Quantitative Content Analysis

To gain an understanding of the approaches and conditions that create value, the literature was analysed utilising a quantitative content analysis on empirical papers, as it enables an analysis with multiple concurring factors and is useful for large datasets such as ours. We tested the approaches and conditions that form our conceptual framework to understand whether this set of variables creates value for resource-constrained SMEs and/or has a measurable impact on the SDGs. Our coding scheme represents the specified phenomena of FBA and Sustainability, we used dichotomous questions to make a code book, which we then could code by making designated notations of each of the conditions when they appeared or were absent in case studies (Coe & Scacco, 2017).

According to Krippendorff (2018), codebooks should use exhaustive variable lists. The protocol was followed. The presence of an FBA was determined through the presence of VRIN attributes of four factors distilled from theory, represented by dichotomous questions. We used clear cut-offs for any unclear variables, such as commercial success, which was achieved if an innovation was maintaining sales for two years after the launch. Other factors were also coded according to the type of FBA, Infrastructure, Input, Income, or Sufficiency. Further, we coded the case studies according to the country of origin. Furthermore, we coded cases to determine the assumed existence of a sustainability impact. Here, the presence of SDG impact was determined through the delta SDG. The presence of SDG delta was determined through the FBA case having an assumed impact on the SDG through the 'creative destruction' of similar non-frugal business models/products/services, but with a positive impact on an SDG. The first two authors coded and rated each case to determine the presence of SDG impact. This was ascribed to a code of 0 for no impact on any SDG. The remaining were coded based on the respective SDG number. Thus, a 1 for an impact on SDG 1, following the same logical progression a 2 was ascribed to the delta SDG that impacted SDG2, ultimately forming a code book where each SDG impacted had a number ascribed to it. Thus, we could conduct further descriptive statistical analysis by determining not only the presence of impact but also the areas of sustainability that were most positively impacted, as having more than one impact on the delta SDG was possible. The codes were added to Microsoft Excel columns, which tracked all the literary entries found from the systematic literature selection. Both authors performed this initial set of coding to ensure reliability. We coded each case study systematically with three iterations for separate coders (again to ensure reliability). All coders have extensive experience in management theory, business models, and financial calculations. Using this systematic coding scheme, we categorised the determination of these two approaches. We further supplemented the information on case studies by googling SMEs that produced the FIs to determine whether the innovation was still commercially successful. We then observed a simple frequency count of the number of cases with the assumed presence of FBA and delta SDG. We then performed a descriptive relational analysis (Huxley, 2020) to understand the relationship between the two, and whether the conditions we deduced would result in an outcome in which both approaches create simultaneous and lasting values. This form of systematic methodology is more reproducible and objective, rendering the findings more valid, consistent, and reliable (Hunter and Schmidt, 2004; Stanley and Temple, 2008).

5. Findings

The following section outlines the results obtained by testing the conditions of our conceptual model. The first subsection 5.1 outlines the descriptive attributes found in the cases, such as the types of innovations that emerged and SDGs that were impacted. The second subsection 5.2 presents a table of conditions and approaches that lead to frugality-based advantages with multiple-value creation.

5.1. Descriptives of Cases

Please refer to the Appendix for a list of all articles (Section A) and cases (Section C). Our findings characterise the context and processes of Frugal Innovations, resulting from the integrative evidence-based synthesis of 37 articles that have reported on 79 unique frugal innovations. Table 1 presents a structured summary of the main findings across frugal innovation case studies. It categorizes the findings according to the frugality-based advantage (FBA) framework, linking frugality conditions, SDG impact, and value creation. The classification follows the taxonomy of internal and external frugality constraints and examines their implications for sustainability and business advantage.

Table 1. Main Findings

Main Findings	
Papers with FI cases: General explanation on the cases (see Appendix, Section C)	
	The reviewed papers cover a broad range of frugal innovation (FI) applications across industries, including healthcare, energy, consumer goods, and manufacturing. Many studies focus on frugal innovation in emerging economies, but there is growing attention on developed economies as well. There is limited empirical testing of how FI leads to sustainable competitive advantage, though some studies provide conceptual frameworks. Business model innovation appears as a key enabler for FI (e.g., rental models, sufficiency-based approaches, and modular product designs). Many papers align FI with sustainability, some with the SDGs, but the link remains weakly quantified. Many studies emphasize cost-reduction and simplification as the defining characteristics of FI. Diffusion patterns suggest that FI adoption outside of its originating context is challenging but possible with the right institutional conditions. There is a divide in how FI is viewed: some see it as a bottom-up necessity in developing markets, others as a strategic choice in developed economies. Frugality-based advantages (FBA) remain underexplored—few studies provide concrete metrics for measuring competitive advantage through FI.
FI cases mentioned in the papers in relation to the Framework dimensions (see Appendix, Section A)	
General	*Frugal Innovation is predominantly studied in developing nations (52 cases, 66%), compared to developed nations (27 cases, 34%). The most common constraint driving FI is infrastructure limitations (35 cases, 44%), followed by input constraints (22 cases, 28%). Income constraints (6 cases, 8%) and sufficiency-driven innovations (16 cases, 20%) are relatively less frequent.*
Firm Resource constraints	*Input Constraints are often due to scarcity of raw materials, supply chain inefficiencies, or weak local manufacturing capabilities. Some developed-world cases (3 cases, 14%) reflect sustainability-driven constraints, such as efforts to minimize resource consumption or use alternative materials. Many frugal innovations stem from organizational constraints, such as lack of capital, R&D limitations, or supply chain inefficiencies. Some firms develop FI by leveraging local resources creatively (e.g., using agricultural waste for energy solutions). Business model frugality plays a role, particularly in service-based innovations (e.g., repair services, clothing rentals, and energy efficiency services).*
Firm environmental resource constraints	*Infrastructure limitations are the dominant driver of FI in developing nations, reinforcing the idea that FI often compensates for systemic deficiencies (e.g., unreliable electricity, poor transportation networks). External constraints often trigger radical simplifications in product design (e.g., low-cost medical devices and off-grid energy solutions). FI solutions typically emerge in response to infrastructure gaps, such as lack of electricity, clean water, or access to healthcare.*

FBA conditions	*The VRIN attributes (Valuable, Rare, Inimitable, Non-substitutable) apply unevenly across cases. Many FIs provide value to customers but are easily imitable, limiting their long-term competitive advantage. Some successful FIs have achieved longevity due to strong market positioning and customer trust.*
SDGs' conditions	*Frequently connected SDGs in the case studies (more than 20 cases): In the cases associated with Frugal Innovations, the most frequently referenced Sustainable Development Goals (SDGs) include: SDG 3 - Good Health and Well-being: Ensure healthy lives and promote well-being for all at all ages; SDG 7 - Affordable and Clean Energy: Ensure access to affordable, reliable, sustainable, and modern energy for all; SDG 9 - Industry, Innovation and Infrastructure: Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation; SDG 12 - Responsible Consumption and Production: Ensure sustainable consumption and production patterns.* *Moderately connected SDGs (10 to 20 cases): SDG 8 - Decent Work and Economic Growth: Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all; SDG 10 - Reduced Inequalities: Reduce inequality within and among countries; SDG 11 - Sustainable Cities and Communities: Make cities and human settlements inclusive, safe, resilient, and sustainable; SDG 13 - Climate Action: Take urgent action to combat climate change and its impacts.* *Least connected SDGs (fewer than 10 cases): SDG 1 - No Poverty: End poverty in all its forms everywhere; SDG 2 - Zero Hunger: End hunger, achieve food security, and promote sustainable agriculture; SDG 4 - Quality Education: Ensure inclusive, equitable, and quality education for all; SDG 5 - Gender Equality: Achieve gender equality and empower all women and girls; SDG 6 - Clean Water and Sanitation: Ensure access to water and sanitation for all; SDG 14 - Life Below Water: Conserve and sustainably use oceans and marine resources; SDG 15 - Life on Land: Protect, restore, and promote sustainable use of terrestrial ecosystems; SDG 17 - Partnerships for the Goals: Strengthen global partnerships to support sustainable development.* *Not connected: SDG 16 - Peace, Justice and Strong Institutions: Promote peaceful and inclusive societies, ensure access to justice for all, and build effective, accountable institutions.*
Value Type 1 (Firm)	*Firm-level value: FI improves cost efficiency and market reach, but long-term profitability cannot be established. 74 cases achieved this type of value for the firm.*
Value Type 2 (Customer)	*FI often translates to lower costs and higher accessibility, particularly for healthcare and energy solutions. 58 cases achieved this type of value for the customer.*
Value Type 3 (Society)	*Society-level value: The impact seems strong in waste reduction, energy efficiency, decent work, and healthcare accessibility. 78 cases achieved this type of value for society.*

The findings suggest that frugal innovations seem to provide significant value for firms, customers and society, but firms might struggle to sustain long-term competitive advantage unless the innovation is difficult to imitate. Many FI cases align well with SDG goals, particularly in waste reduction, energy efficiency, and healthcare access. A key challenge for SMEs using FI is maintaining a balance between affordability and long-term business viability.

5.2. FBA determination; Examining the Framework

Our primary finding is displayed below in Table 2. The table presents a model of conditions and approaches that create an FBA that is sustained, competitive, and beneficial to society. This is the result of comparing the conceptual framework with all the conditions and approaches presented with the subsequent coding results. Table 2 shows that if all four conditions were met, a sustained frugality-based advantage was achieved; the bottom two rows of the table depict how many Frugal Innovations achieved this. The results show that of the 79 cases analysed, 53 were able to achieve sustained competitive Frugality-Based Advantages. These 53 cases that met all four conditions of the first approach (FBA), were then coded to see if they also met the conditions of societal impact. Of particular note, 51 of the 53 cases that created financial value for the owners (Sustained FBA) also

produced societal impact (see Table 2). Thus, it can be construed that Sustained FBA is strongly related to Societal FBA.

An example of a Frugal Innovation that meets all the conditions (all coded 'Yes') for a frugality-based advantage that also creates social value by adding to one or more of the SDGs involves the company MittiCool. MittiCool was founded by Mansukhbhai Prajapati in Gujarat, India. The company's flagship product is a clay refrigerator that operates without electricity using the natural cooling effect of evaporation (Hossain, 2021, p. 3). This innovation is highly suitable for areas with no power supply, creating value for customers by overcoming the lack of availability of particular inputs, in this case, electrical energy infrastructure (Asakawa et al., 2019). It has gained international recognition for its sustainable and environmentally friendly approach, adding to SDG12 (food waste) which could be measured in kilograms of avoided food waste, and SDG7 (access to energy) which could be in the number of people who use this appliance.

However, not every frugal innovation mentioned created value for customers like MittiCool does. Nor does every FI get around the lack of availability of a particular Rare input, solving a resource constraint. Not every FI has shown commercial success for more than two years. This could be because it was possible to Imitate or it was possible to solve the constraint with other innovations (non-substitutable). Innovations that did not meet these conditions, were therefore coded with 'No' and ultimately did not meet the criteria for an FBA.

The results of this coding process are presented in Table 2.

Table 2. FI-cases and the conditions for a sustained frugality-based advantage and creating value for society

Conditions for multiple value creation from resource constraints by SMEs. Does the Frugal Innovation create a Frugality Based Advantage that creates multiple values?							
Approach 1: Frugality Based Advantage (FBA)						**Approach 2: ΔSDG**	
Condition 1 **V- The Frugal Innovation helps to overcome a resource constraint which creates value for the customer (Asakawa et al., 2019).**	**Condition 2** **R-Does the FI focus on getting around the lack of availability of particular ('RARE') inputs and finding new ways of substituting their use (Asakawa et al., 2019).**	**Condition 3** **I- It is difficult to IMITATE the FI, meaning other firms can't easily copy it because of unique historical context, causal ambiguity and social complexity (Barney, 1991; Asakawa et al., 2019).**	**Condition 4** **N- Non-substitutable, competitors find it difficult to solve the constraint with other innovations (Barney, 1991; Asakawa et al., 2019).**		*Financial value creation for the owners (economic performance)*	**Condition 5** **SDG: Does the Frugal Innovation add positive value to one or more of the SDGs?**	**Condition 6** **Δ (Delta). Can the change on the SDGs be measured (Kraaij et al., 2023)?**	*Value creation for society*
No (6)	-	-	-		No FBA	No (1)	No (1)	No societal value creation
Yes	No (4)	-	-					
Yes	Yes	No (14)	-		Temporary FBA			
Yes	Yes	Yes	No (2)	Yes (53)	Sustained FBA	Yes	Yes	Societal FBA
Yes = 73	**69**	**55**	**53**			**52**	**51**	**51**
No = 6	4	14	2			1	1	

6. Discussion

From our research question, 'What are the approaches and conditions for small businesses to create multiple values from a resource constraint?', we were able to discern a conceptual framework distilled from theory. The meta-synthesis demonstrates that Frugal Innovations, which meet the identified conditions from the two approaches (FBA and SDG Delta), lead to value creation.

From the dataset, we discern two clear forms of value creation from FI to address severe resource constraints. First, we can conclude that an FI that meets the adapted VRIN conditions creates financial value for the SME. This was determined by analysing the value creation aspects, dealing with a resource constraint, and the fact that the SME was able to sustain its commercial advantage for a minimum of two years. The number of FIs that conformed to the first four conditions was 67% (of the 79 selected cases). Thus, we can determine that most Frugal Innovations create a sustained frugality-based advantage for SMEs, meaning they can be sustained over a period of at least two years. As such, FI is

well suited for creating sustained value-based ventures that support resource-constrained SMEs. Second, we tried to understand societal value creation by checking if the FI was adding to one or more of the SDGs and that the effect could be measured. Through the coding process, it was determined that nearly all FIs that were able to create financial value were also able to create this second form of societal value. From this perspective, our results suggest that an FI and its value creation from society's resource constraints can have a significant impact on the SDGs. This encapsulates value creation for society. Neesham et al. (2023) define this value creation as Tri-profit value which is a term that encompasses value creation in social, economic and ecological aspects (Neesham et al., 2023). As outlined earlier, we refer to this as the term 3BL, in which the balancing act is achieved in the creation of social, economic, and environmental value creation (Kumar, 2020). This balancing act can be deemed an inherent paradox yet presents as an opportunity for 3BL.

It is important to note that the adoption of FI by developed countries has attracted criticism, as scholars like Tesfaye and Fougère (2022) and Chakravarty and Gómez (2024) caution against co-opting FI away from its intended purpose. Nonetheless, we argue that FI can effectively address distinct needs across contexts, although it is essential to prevent any narrative from dominating (Tesfaye and Fougère, 2022; Chakravarty and Gómez, 2024). Notably, product innovations are predominant in both contexts, in line with recent literature on product-oriented FI (Lange et al., 2023). The findings suggest that the regional context (developing versus developed) significantly shapes the type and sustainability of frugality-based advantages (FBAs) achieved. Developing countries primarily generate infrastructural FBAs to address foundational resource gaps, often leading to innovations that support income growth by reducing costs. By contrast, developed countries frequently create crisis-driven FBAs, such as sufficiency-focused innovations for long-term sustainability, although these may lack durability if tied to specific crises. This contextual variation implies that the effectiveness and longevity of FBAs depend on the unique challenges and catalysts of each environment. Therefore, our research suggests that while FI can be a valuable approach across contexts, the drivers and durability of value creation through FI vary, underscoring the importance of context-specific approaches for maximising both forms of impact of the above conditions.

While this study confirms that Frugal Innovation can generate both financial and societal value, the long-term sustainability of these advantages remains uncertain. Many FI solutions are highly imitable, making their competitive advantage short-lived unless firms effectively leverage external resources and strategic partnerships. This aligns with The Extended Resource-Based View (Mathews, 2003; Chiang, 2021), which emphasizes that firms operating under resource constraints can achieve a sustained advantage by accessing external networks, institutional support, and ecosystem-based collaborations.

Additionally, the effectiveness of FI varies by context: while infrastructure-driven frugality is more prevalent in developing nations, sufficiency-based FI is more relevant in developed economies (Niessen & Bocken, 2021). Future research should explore how SMEs can enhance resilience by integrating FI with inter-firm cooperation, public-private partnerships, and cross-sector innovation ecosystems.

7. Conclusion

7.1. Contribution to Theory and Practice

From our study, we make contributions to the academic discourse on Frugal Innovation. First, we aimed to contribute to Asakawa et al. (2019) and their paper on the concept of FBA, primarily to continue refining the concept as requested by the authors. We have tried to do this in the context of SMEs, providing empirical proof of FBAs' conditions and the value that Frugal Innovations can create. Furthermore, we contribute to the conceptualisation of FBA by operationalising the VRIN conditions in the context of FBA. In this process, we connect the Resource-based View of the firm to Frugal Innovation. In doing so, we filled the research gap identified by Dabić et al. (2022).

Second, this study proposes a comprehensive framework to assess the multidimensional impacts of frugal innovations, encompassing economic benefits for SMEs, as well as social and environmental outcomes. By integrating quantitative and qualitative metrics, this framework aims to capture the breadth of frugal innovations' contributions to the Sustainable Development Goals (SDGs). In doing so, we further contribute to a gap identified by Kumar (2020, p. 494), who highlights that "empirical studies probing the processes and mechanisms used by sustainable ventures to manage inherent tensions are limited". In presenting an empirical study of case studies that achieve this balancing act of 3BL value creation, we further contribute to this realm. This also contributes to the work of Le Bas (2023a) by providing the conditions of FI that have a sustainability impact and which form of sustainability impact is achieved.

Finally, our contribution to practice is that we lay the groundwork for the creation of practical applications that could assist SMEs in developing an FI that creates a frugality-based advantage.

7.2. Limitations

As in any other study, there are several limitations to our study. In deploying a meta-synthesis of papers with cases for our methodology, there is a degree of subjectivity to consider. This occurs on two fronts: first, in the subjectivity of the authors coding and analysing the meta-synthesis, and also in the fact that we are only studying cases that have been published in quality journals. We attempted to mitigate the former by using three separate coding iterations and three different

reviewers. The latter was addressed by systematically accumulating a broad range of literature to ensure that minimal relevant information was excluded. Even so, it would be impossible to analyse all cases of FI, as not every Frugal Innovation has been documented in peer-reviewed journal articles.

A limitation of this methodology is that the predominant proportion of papers describes case studies that have been collated from secondary sources, which is limited as it becomes less scrupulous. However, we attempted to overcome this issue using high-quality peer-reviewed journals. Furthermore, many case studies appear multiple times, making it easier to verify the accuracy of the presented case.

Another limitation, which was more difficult to address, was the limited information available for some cases. Although we attempted to eliminate papers in our selection process, cases that had sufficient information to code did not necessarily mean that they had specific enough information for each case, leaving room for interpretation and, ultimately, error. For instance, it was sometimes difficult to discern firm size from the information provided in the case and therefore needed to be complemented with additional research. Furthermore, it was unclear which SDGs the FIs impacted, leaving this to the coder's interpretation. SDGs have been used as metrics for eco-societal impact in previous studies (Dressler & Bucher, 2018; Levänen et al., 2016). This is a difficult attribute to capture because it is somewhat subjective and requires great diligence to discern the main contribution to the SDGs.

A critical limitation is that some of the VRIN conditions are difficult to measure. In particular, to discern whether an FI was non-imitable and easy to substitute, we judged whether there was commercial success, and if there was, we assumed that it was met; however, there are other factors that could have influenced the failure of an FI. Furthermore, some FIs were easy to substitute but still able to achieve commercial success simply because of the context in which they operate.

Another limitation is our use of developed nations as case studies, which stems from Tesfaye and Fougère (2022) and Chakravarty and Gómez (2024), who criticise the adoption of the concept in a Western context. It is postulated that this co-opting will lead to a dominant understanding and the original intentions of FI may be lost. We have tried to mitigate this to an extent by using cases from both sets and by understanding the different contexts and spaces in which they operate. Building on this, it is also highlighted that it is not just an issue of resource overuse, as it is deployed in the developed context; many of the resource constraints in the developing world are due to the inequitable distribution of resources across the globe. However, as our study focused on value creation from frugality, this was outside of our scope, although we recommend exploring this notion further within the context of FI in future studies.

A further limitation of this study lies in potential biases in case selection and analysis, as our dataset is drawn from the published literature, which may overrepresent certain types of Frugal Innovations (FIs) and contexts. This

reliance on secondary sources could introduce selection bias, as cases with significant outcomes are more likely to be documented, potentially skewing our understanding of FI's typical impact. Additionally, the qualitative nature of case studies makes it challenging to ensure objectivity in coding and interpreting findings, which may reflect researchers' subjective perspectives. Finally, the specific conditions and contexts of individual case studies limit the generalisability of our results, as the findings may not fully apply across diverse SME environments or larger organisations.

Finally, a limitation exists in the use of RBV in its current form. While the RBV has provided valuable insights into how firms leverage internal resources for competitive advantage, recent developments in strategic management literature suggest the need for broader perspectives that incorporate external and dynamic resource configurations. The Extended Resource-Based View (Mathews, 2003; Chiang, 2021) expands the RBV by considering not only internal resources but also external networks, dynamic capabilities, and resource recombination as critical drivers of competitive advantage, which are particularly relevant for SMEs operating in resource-constrained environments. Although this was beyond the scope of our current study, there are clear links between our FI typologies present here. Given that many FI case studies in our dataset succeeded through collaborative ecosystems, such as industry alliances or government initiatives, incorporating the Extended Resource-Based View provides a more holistic understanding of how FI can achieve long-term sustainability. As such, future studies could extend the conceptual model created and tested in this paper through applying the Extended Resource-Based View as an extended version of RBV with a more applied focus.

7.3. Future Steps

As the discussion around Frugal Innovation (FI) grows, there is an increasing need to establish a standardized framework to ensure its applicability across different contexts (Sarkar and Mateus, 2022). Currently, FI research remains fragmented, with varying definitions and inconsistent theoretical underpinnings. Future studies should aim to refine FI's conceptual boundaries and its integration within broader innovation theories, particularly in developed economies.

Frugal Innovation originally emerged in developing countries and is driven by the need to create affordable and accessible solutions under resource constraints. However, recent research suggests that FI may also hold significant potential in developed or advanced economies (Leliveld et al., 2023). Thus, a critical question to address is how frugal innovation integrates with and expands upon existing innovation theories in the context of resource constraints in developed countries. By exploring this integration, frugal innovation frameworks can be further developed theoretically and applied practically to enhance the resilience and sustainability of small and medium-sized enterprises (SMEs) in

developed economies. This approach aims to position FI as a valuable component of innovation strategies that drives sustainable growth and competitive advantage in resource-limited contexts.

Second, we need to identify the challenges and cognitive mechanisms entrepreneurs employ to navigate resource scarcity and set the foundation for further development of practical tools for SMEs. It is necessary to establish clear objectives and tailored design principles that will act as pragmatic, context-specific heuristics for the development of tangible Frugal Business Model Innovation tools (e.g. workshops, gamification tools and business model patterns) designed to assist SMEs in navigating resource constraints and create an FBA.

Finally, the extent of the sustainability impact of FIs and how to capture its value need to be explored in future studies. This can be achieved by designing practical tools and frameworks for SMEs that measure impact and helps them develop their FBA. This can be achieved through quantitative studies like surveys or financial performance analysis that empirically validate the conceptual framework presented in this study, particularly concerning the conditions under which frugal innovations (FIs) generate sustainable value. Quantitative approaches can provide objective measurements of frugality-based advantages (FBAs) and their impact on competitive advantage and sustainability outcomes, strengthening the generalisability of these findings.

In summary, we have built a large unique dataset in which we distilled several conditions of what makes an FI an FBA and the subsequent value creation (therefore gaining an answer to our research question). However, there are still several avenues to pursue in the FI discourse before we can understand the full extent of its use for SMEs.

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APPENDIX

A. List of innovation cases (79) and their corresponding source articles (37)

#	Innovation	Article	Authors	Year	Journal
1	Pre-screening device to detect preventable blindness early	Business Models for Frugal Innovation in Emerging Markets: The Case of the Medical Device and Laboratory Equipment Industry	Winterhalter, S; Zeschky, MB; Neumann, L; Gassmann, O	2017	Technovation
2	Portable infectious disease detection device	Business Models for Frugal Innovation in Emerging Markets: The Case of the Medical Device and Laboratory Equipment Industry	Winterhalter et al.	2017	Technovation
3	Portable, affordable Microscope	Business models for sustainable innovation - an empirical analysis of frugal products and services	Rosca, E; Arnold, M; Bendul, JC	2017	Journal of Cleaner Production
4	ATM for rural areas	Can frugal go global? Diffusion patterns of frugal innovations	Hossain, M; Simula, H; Halme, M	2016	Technology in Society
5	Aggregation and distribution of sorghum	Connecting the Concepts of Frugality and Inclusion to Appraise Business Practices in Systems of Food Provisioning: A Kenyan Case Study	Vellema, S; Schouten, G; Knorringa, P	2023	Journal of Agricultural & Environmental Ethics
6	Water filter using reverse osmosis technology.	Constraint-Based Thinking: A Structured Approach for Developing Frugal Innovations	Agarwal, N; Oehler, J; Brem, A	2021	IEEE Transactions on Engineering Management
7	Job creation in rural areas by frugal craft breweries	Crafting growth together	Dodd, S; Wilson, J; Karampela, M; Danson, M	2021	Entrepreneurship & Regional Development
8	Recognized qualifications aiding recruitment local businesses	Crafting growth together	Dodd et al.	2021	Entrepreneurship & Regional Development
9	Engagement with customers and distributors local breweries	Crafting growth together	Dodd et al.	2021	Entrepreneurship & Regional Development
10	Maintaining authenticity in global markets for craftbeer	Crafting growth together	Dodd et al.	2021	Entrepreneurship & Regional Development
11	Shared production facilities and knowledge	Crafting growth together	Dodd et al.	2021	Entrepreneurship & Regional Development
12	Biomass Gasifier	Crafting Sustainable Development Solutions: Frugal Innovations of Grassroots Entrepreneurs	Pansera M; Sarkar S	2016	Sustainability
13	Pad machine	Crafting Sustainable Development Solutions: Frugal Innovations of Grassroots Entrepreneurs	Pansera M; Sarkar S	2016	Sustainability
14	Mobile drug authentication	Creating social value through frugal innovation (book chapter)	Kuo, A	2014	Entrepreneurship in Asia: Social Enterprise, Network and Grassroots Case Studies (edited volume)
15	Low-speed EV	Depreciated in Policy, abundant in Market? The Frugal Innovation of the Chinese low-speed EV industry	Lu, C; Chang, F; Rong, K; Shi, Y; Yu, X	2020	International Journal of Production Economics
16	Electric Automobiles	Depreciated in Policy, abundant in Market? The Frugal Innovation of the Chinese low-speed EV industry	Lu et al.	2020	International Journal of Production Economics

17	Frugal Lithium Battery for E-bike	Depreciated in Policy, abundant in Market? The Frugal Innovation of the Chinese low-speed EV industry	Lu et al.	2020	International Journal of Production Economics
18	Frugal ESN product	Developing Frugal IS Innovations: Applied insights from Weqia.com	Sun, Y; Cao, HY; Tan, B; Shang, RA	2016	International Journal of Information Management
19	Low-cost cooling solution	Frugal Entrepreneurship: Profiting with Inclusive Growth	Hossain, M; Sarkar, S	2021	IEEE Transactions on Engineering Management
20	Jaytree sanitary napkin manufacturing machine	Frugal Entrepreneurship: Profiting with Inclusive Growth	Hossain, M; Sarkar, S	2021	IEEE Transactions on Engineering Management
21	Low-cost milking machine	Frugal Entrepreneurship: Profiting with Inclusive Growth	Hossain, M; Sarkar, S	2021	IEEE Transactions on Engineering Management
22	Bamboo machine	Frugal Entrepreneurship: Profiting with Inclusive Growth	Hossain, M; Sarkar, S	2021	IEEE Transactions on Engineering Management
23	Cotton-stripping machine	Frugal Entrepreneurship: Profiting with Inclusive Growth	Hossain, M; Sarkar, S	2021	IEEE Transactions on Engineering Management
24	Crowdfunded film production	Frugal innovation and digital effectuation for development: The case of Lucia	Khanal, PB; Aubert, BA; Bernard, JG; Narasimhamurthy, R; Dé, R	2022	Information Technology for Development
25	Bloodless home-based dialysis machine	Frugal innovation as a source of sustainable entrepreneurship to tackle social and environmental challenges	Shahid, MS; Hossain, M; Shahid, S.; Anwar, T	2023	Journal of Cleaner Production
26	Eco-friendly sanitary napkins	Frugal innovation as a source of sustainable entrepreneurship to tackle social and environmental challenges	Shahid et al.	2023	Journal of Cleaner Production
27	Medical consultation kiosk	Frugal innovation as a source of sustainable entrepreneurship to tackle social and environmental challenges	Shahid et al.	2023	Journal of Cleaner Production
28	Electric motorbikes	Frugal innovation as a source of sustainable entrepreneurship to tackle social and environmental challenges	Shahid et al.	2023	Journal of Cleaner Production
29	Prefab sustainable housing	Frugal innovation as a source of sustainable entrepreneurship to tackle social and environmental challenges	Shahid et al.	2023	Journal of Cleaner Production
30	Detachable water filters	Frugal innovation as a source of sustainable entrepreneurship to tackle social and environmental challenges	Shahid et al.	2023	Journal of Cleaner Production
31	Low-cost bicycles	Frugal innovation for the BoP in Brazil — an analysis and comparison with Asian lead markets	Wimschneider, C; Agarwal, N; Brem, A	2020	International Journal of Technology Management
32	Nanotechnology in cosmetics	Frugal innovation for the BoP in Brazil — an analysis and comparison with Asian lead markets	Wimschneider et al.	2020	International Journal of Technology Management
33	Digital, software-based equipment	Frugal innovation for the BoP in Brazil — an analysis and comparison with Asian lead markets	Wimschneider et al.	2020	International Journal of Technology Management
34	3D-printed ventilator valves and CPAP masks	Frugal innovation in a crisis: the digital fabrication maker response to COVID-19	Corsini, L; Dammicco, V; Moultrie, J	2021	R&D Management
35	Process innovation in SWH manufacturing	Frugal innovation in energy transitions: Insights from solar energy cases in Brazil	Busch, HC	2021	Cambridge Journal of Regions, Economy and Society
36	Embrace inflatable low-cost incubator	Frugal innovation: Conception, development, diffusion, and outcome	Hossain, M	2020	Journal of Cleaner Production
37	Clay refrigerator (MittiCool)	Frugal innovation: Conception, development, diffusion, and outcome	Hossain, M	2020	Journal of Cleaner Production

38	mOm infant incubator	Frugal innovation: Conception, development, diffusion, and outcome	Hossain, M	2020	Journal of Cleaner Production
39	Wick machine	Frugal innovation: Conception, development, diffusion, and outcome	Hossain, M	2020	Journal of Cleaner Production
40	Cotton stripping machine	Frugal innovation: Conception, development, diffusion, and outcome	Hossain, M	2020	Journal of Cleaner Production
41	Sustainable lighting/Nuru Energy	Frugal innovation: Conception, development, diffusion, and outcome	Hossain, M	2020	Journal of Cleaner Production
42	Solar solutions SELCO	Frugal innovation: Conception, development, diffusion, and outcome	Hossain, M	2020	Journal of Cleaner Production
43	Solar energy solutions BOOND	Frugal innovation: Conception, development, diffusion, and outcome	Hossain, M	2020	Journal of Cleaner Production
44	Affordable Hepatitis B vaccine	Frugal Innovation: Learning from Social Entrepreneurs in India (Research Report)	Singh, SK; Gambhir, A; Sotiropoulos, A; Duckworth, S	2012	The Serco Institute Available at SSRN: https://ssrn.com/abstract=2026330
45	Bamboo shoots, shift in processing	Frugal Innovations and Actor-Network Theory: A Case of Bamboo Shoots Processing in Manipur, India	Devi, WP; Kumar, H	2018	European Journal of Development Research
46	Quicker fermentation method (Bishempur type)	Frugal Innovations and Actor-Network Theory: A Case of Bamboo Shoots Processing in Manipur, India	Devi, WP; Kumar, H	2018	European Journal of Development Research
47	Packaging and processing of bamboo shoots	Frugal Innovations and Actor-Network Theory: A Case of Bamboo Shoots Processing in Manipur, India	Devi, WP; Kumar, H	2018	European Journal of Development Research
48	Telemedicine-based primary care	Global Lessons in Frugal Innovation to Improve Health Care Delivery in the United States	Bhatti, Y; Taylor, A; Harris, M; Wadge, H; Escobar, E; Prime, M; Patel, H; Carter, AW; Parston, G; Darzi, AW; Udayakumar, K	2017	Health Affairs
49	Biodegradable Toothbrush	Harnessing frugal innovation to foster clean technologies	Kuo, A	2017	Clean Technologies and Environmental Policy
50	Motorized seeder for efficient agriculture	How does frugal innovation emerge and lead to sustainability in developing countries? A case study in Malian agricultural areas	Sissoko, M; Castiaux, A	2018	AgEcon Search: Research in Agricultural & Applied Economics
51	Pedal generator for energy	How Frugal Innovation and Inclusive Business are linked to tackle low-income markets	Lange, A; Hüsig, S; Albert, M	2023	Journal of Small Business Management
52	Biogas plant using cow dung	How Frugal Innovation and Inclusive Business are linked to tackle low-income markets	Lange et al.	2023	Journal of Small Business Management
53	Sustainable local energy solutions	How Frugal Innovation Promotes Social Sustainability	Khan, R	2016	Sustainability
54	Simple and ease to repair smartphone	How to make more of less: Characteristics of sufficiency in business practices	Beyeler, L; Jaeger-Erben, M	2022	Frontiers in Sustainability
55	Clothing library	How to make more of less: Characteristics of sufficiency in business practices	Beyeler, L; Jaeger-Erben, M	2022	Frontiers in Sustainability
56	Online renting of clothing	How to make more of less: Characteristics of sufficiency in business practices	Beyeler, L; Jaeger-Erben, M	2022	Frontiers in Sustainability
57	Repair workshops of clothing	How to make more of less: Characteristics of sufficiency in business practices	Beyeler, L; Jaeger-Erben, M	2022	Frontiers in Sustainability
58	Community-based platform for repair instructions	How to make more of less: Characteristics of sufficiency in business practices	Beyeler, L; Jaeger-Erben, M	2022	Frontiers in Sustainability
59	Repair service appliences	How to make more of less: Characteristics of sufficiency in business practices	Beyeler, L; Jaeger-Erben, M	2022	Frontiers in Sustainability

60	Recycle clothing fabric	How to make more of less: Characteristics of sufficiency in business practices.	Beyeler, L; Jaeger-Erben, M	2022	Frontiers in Sustainability
61	Modular smartphone	How to make more of less: Characteristics of sufficiency in business practices.	Beyeler, L; Jaeger-Erben, M	2022	Frontiers in Sustainability
62	Biomass Gasification	Implications of Frugal Innovations on Sustainable Development: Evaluating Water and Energy Innovations	Levänen, J; Hossain, M; Lyytinen, T; Hyvärinen, A; Numminen, S; Halme, M	2016	Sustainability
63	Mobile hand sanitizer	Innovation and entrepreneurship in India: Understanding jugaad	Prabhu, J; Jain, S	2015	Asia Pacific Journal of Management
64	Modular refrigerator	Modularity as a support for frugal product and supplier network co-definition under regional market constraints: A mirroring hypothesis application	Belkadi, F; Vlachou, E; Kumar-Gupta, R; Zogopoulos, V; Kaya, M; Bernard, A; Mourtzis, D; Natalizio, S; Büyükdigan, BG; Bayrak, IT	2018	International Journal of Production Research
65	Water-purification process	The circular economy and resource use reduction: A case study of long-term resource efficiency measures in a medium manufacturing company	Konash, A; Nasr, N	2022	Cleaner Production Letters
66	Expansion and franchising of schools.	The co-creation of social ventures through bricolage, for the displaced, by the displaced	Cheung, CWM; Kwong, C; Manzoor, H; Rashid, MU; Bhattarai, C; Kim, YA	2019	International Journal of Entrepreneurial Behavior & Research
67	Bicycle sharing/ subscription service.	The impact of business sufficiency strategies on consumer practices: The case of bicycle subscription	Niessen, L; Bocken, N; Dijk, M	2023	Sustainable Production and Consumption
68	Solar Powered ATM for rural areas	The social dimension of frugal innovation	Khan, R; Melkas, H	2020	International Journal of Technology Management
69	Electric crane from scrap metal	The Surprising Duality of Jugaad: Low Firm Growth and High Inclusive Growth	Shepherd, DA; Parida, V; Wincent, J	2020	Journal of Management Studies
70	Tomato crushing machine	The Surprising Duality of Jugaad: Low Firm Growth and High Inclusive Growth	Shepherd et al.	2020	Journal of Management Studies
71	Energy-efficient cookstoves and ovens	Toward a Theory on the Reproduction of Social Innovations in Subsistence Marketplaces	Steinfield, L; Holt, D	2019	Journal of Product Innovation Management
72	Double-pit latrine for waste separation.	Toward a Theory on the Reproduction of Social Innovations in Subsistence Marketplaces	Steinfield, L; Holt, D	2019	Journal of Product Innovation Management
73	Affordable laptop designed for children.	Toward a Theory on the Reproduction of Social Innovations in Subsistence Marketplaces	Steinfield, L; Holt, D	2019	Journal of Product Innovation Management
74	Durable, extendable furniture	Towards a sufficiency-driven business model: Experiences and opportunities	Bocken, N; Short, S	2016	Environmental Innovation and Societal Transitions
75	Timeless, high-quality clothing	Towards a sufficiency-driven business model: Experiences and opportunities	Bocken, N; Short, S	2016	Environmental Innovation and Societal Transitions
76	Hydrogen fuel cell-powered vehicle	Towards a sufficiency-driven business model: Experiences and opportunities	Bocken, N; Short, S	2016	Environmental Innovation and Societal Transitions
77	'Unprinting' technology	Towards a sufficiency-driven business model: Experiences and opportunities	Bocken, N; Short, S	2016	Environmental Innovation and Societal Transitions
78	Natural wastewater treatment using biotechnology	Understanding and evaluating the sustainability of frugal water innovations in Mexico: An exploratory case study	Molina-Maturano, J; Bucher, J; Speelman, S	2020	Journal of Cleaner Production
79	Firefighter Cooling vest	University-Industry Collaboration in Frugal Innovation Through Prototyping: The Case of a Firefighter Cooling Vest	Walden, R; Lie, S	2021	IEEE Transactions on Engineering Management

B. Meta synthesis overview (adapted from Hoon, 2013)

Steps	Strategy	Outcome
Selection of a research question	We identified a research question that builds off Asakawa's FBA conceptualization. Aiming to contribute to the operationalization of this concept, as a bridge for FI multiple value creation.	The question discerned: What are the approaches and conditions for small businesses to create multiple values from a resource constraint?
Collating relevant research	We aimed to have a high-quality sample of cases of FI, we searched web of science for the topic Frugal Innov* and complemented this with a google scholar search.	279 Initial articles found.
Inclusion criteria	We developed 5 specific attributes for including articles, a) Qualitive case study, b) Focus on FI, c) size of firm - SME, d) high quality journals only, and finally e) having sufficient information available to code.	Sample was reduced to 37 articles, covering 79 case studies.
Coding	We read each full article and structured coding based around our approaches and conditions as well as other discerning variables like country of origin.	Each article analysed case studies placed in excel.
Analysing on a case level	We coded each case study, based on relevant data discerned in previous step.	Each case study was coded by conditions and approaches.
Synthesizing	We merged duplicate cases together, analysing each case once (based on several article inputs). Themes were coded on FBA dimensions.	Duplicate case studies merged, patterns identified.
Creating theory and propositions from the synthesis	From the dimensions discerned, the framework of conditions and approaches was tested, providing an answer to our research question in the form of a table of which conditions lead to an FBA that creates multiple values.	Framework of conditions and approaches for sustained FBAs with societal impact.
Discussion of results that emerge	We discuss our findings in the context of the problem we wanted to address, as well as identify our contribution to theory in refining FBA. Further in connecting sustainability and theory to FI. Lastly, we address limitations and provide a future research direction.	A discussion that validates the findings as well as identify limitations and key areas of future research.

C. Case details (cases 1-79)

	Innovation	**Frugality of Innovation**	**Type of venture**	**Country of Adoption**	**Business Area**	**Innovation Type**	**Frugality condition (Resource crises)**	**V.R.I.N.?**	**SDGs (#)**	**Value Creation for ….**
	General information on the cases						**Framework**			
1	Pre-screening device to detect preventable blindness early	Device for detecting preventable blindness in rural clinics.	SME (Local firm)	India	Healthcare	Product	Infrastructure	yes/yes/yes/yes	SDG3 SDG10 SDG7	Firm, Customer, Society
2	Portable infectious disease detection device	Device for rapid infectious disease testing in rural healthcare centers.	SME (Local firm)	India	Healthcare	Product	Infrastructure	yes/yes/yes/yes	SDG3 SDG10	Firm, Customer, Society
3	Portable, affordable Microscope	Low-cost, paper-based microscope, enhances access to educational tools	SME (Social enterprise)	Developing countries	Education, Scientific Research	Product	Income	yes/yes/yes/yes	SDG4 SDG9 SDG10	Firm, Customer, Society
4	ATM for rural areas	Solar-powered ATM designed for illiterate users in rural areas	SME (Start-up)	Djibouti, Madagascar, Nepal	Bank services	Product	Infrastructure	yes/yes/yes/yes	SDG7	Firm, Customer, Society
5	Aggregation and distribution of sorghum	Agile sourcing and distribution under resource constraints	SME (Local firm)	Kenya	Agriculture/Food	Business Model	Infrastructure	yes/yes/yes/yes	SDG2 SDG8 SDG 12	Firm, Customer, Society
6	Water filter using reverse osmosis technology.	Cost-effective, simple design for removing pathogens and contaminants from water. It's frugal due to its affordable and accessible technology in resource-limited settings.	SME (Local firm)	India	Water purification and sanitation	product	Infrastructure	yes/yes/yes/yes	SDG6 SDG3 SDG1 SDG11	Firm, Customer, Society
7	Job creation in rural areas Craft breweries	Utilizing local resources and markets for job creation in rural regions	SME (Local firm)	Varied (Global Perspective)	Food (Beverage)	Business Model	Income	yes/yes/no/	SDG8 SDG9	Firm, Society

8	Recognized qualifications aiding recruitment local businesses	Importance of institutional support and sector-recognized qualifications for growth	SME (Local firm)	Varied (Global Perspective)	Food (Beverage)	Process	Infrastructure	no///	SDG4 SDG8	Firm, Society
9	Engagement with customers and distributors local breweries	Building brand and community engagement through customer and distributor relationships	SME (Local firm)	Varied (Global Perspective)	Food (Beverage)	Business Model	Income	no///		Customer
10	Maintaining authenticity in global markets for Craftbeer	Balancing local identity and global market demands for authenticity	SME (Local firm)	Varied (Global Perspective)	Food (Beverage)	Business Model	Sufficiency	no///	SDG12 SDG8	Firm, Customer, Society
11	Shared production facilities and knowledge	Collaborative growth through shared resources and knowledge exchange between craft breweries	SME (Local firm)	Varied (Global Perspective)	Food (Beverage)	Process	Input	yes/no//	SDG9 SDG11	Firm, Society
12	Biomass Gasifier	Simple, uses agricultural waste for energy	SME (GE / Local firm)	India	Energy	Product	Input	yes/yes/yes/ yes	SDG7 SDG11 SDG12	Firm, Customer, Society
13	Pad machine	A low-cost sanitary pad making machine that enables local women to produce affordable sanitary pads	SME (Social enterprise)	India	Hygiene Products	Product	Input	yes/yes/yes/ yes	SDG3 SDG5	Firm, Customer, Society
14	Mobile drug authentication	Simple mobile-based drug verification combatting counterfeit drugs	SME (Social enterprise)	Ghana, Nigeria	Healthcare	Product	Infrastructure	yes/yes/yes/ yes	SDG3 SDG9	Firm, Customer, Society
15	Low-speed EV	Affordable, easy-to-operate EVs for rural areas	SME (Local firm)	China	Transportation	Business Model	Input	yes/yes/no/	SDG7 SDG11	Customer, Society
16	Electric Automobiles	EVs for overseas due to domestic constraints	SME (Local firm)	Initially Overseas, later China	Transportation	Business Model	Sufficiency	yes/yes/no/	SDG8 SDG9 SDG13	Customer, Society
17	Frugal Lithium Battery for E-bike	Lithium-ion battery tech for EVs	SME (Local firm)	China	Energy	Product	Input	yes/no//	SDG7 SDG11	Firm, Society
18	Frugal ESN product	Enterprise SocialNetworking (ESN) products. Developed with minimal resources, focused on essential features and user needs	SME (Start-up)	China	Software	Business model	Input	yes/yes/yes/ yes	SDG8 SDG9 SDG10	Firm, Customer, Society
19	Low-cost cooling solution	No electricity needed, uses traditional clay pots.	SME (University + Local firm)	Nigeria	Agriculture	Product	Infrastructure	yes/yes/yes/ yes	SDG2 SDG3	Firm, Customer, Society
20	Jaytree sanitary napkin manufacturing machine	Frugal sanitary napkin machine enabling women to produce affordable sanitary products.	SME (Social enterprise)	Various	Healthcare	Product	Infrastructure	yes/yes/yes/ yes	SDG3 SDG10 SDG1	Firm, Customer, Society
21	Low-cost milking machine	Simple technology improving dairy farming efficiency and hygiene, making it accessible to small farmers.	SME (Grassroots entrepreneurs / Local firm)	India	Agriculture	Product	Input	yes/yes/yes/ yes	SDG2 SDG8	Firm, Customer, Society
22	Bamboo machine	Automates bamboo splint making, rural industry support	SME (Local firm)	India	Consumer Products	Product	Input	yes/yes/no/	SDG8 SDG9	Firm, Society
23	Cotton-stripping machine	Reduced labor costs and increased efficiency	SME (Local firm)	Not Specified	Agriculture/Textile	Product	Input	yes/yes/yes/ yes	SDG8 SDG9	Firm, Customer, Society
24	Crowdfunded film production	Utilized crowdfunding and crowdsourcing, minimizing production and distribution costs	SME (GE / Local firm)	India	Entertainment (Film Industry)	Business Model	Input	no///	SDG8 SDG9 SDG11	Society
25	Bloodless home-based dialysis machine	Cost-effective, lean infrastructure, local materials, low mechanization.	SME (Start-up)	Pakistan	Healthcare	Product	Infrastructure	yes/yes/yes/ yes	SDG3 SDG9	Firm, Customer, Society
26	Eco-friendly sanitary napkins	Eco-friendly, health-conscious, organic cotton, biodegradable.	SME (Local firm)	Pakistan	Hygiene products	Product	Sufficiency	yes/yes/yes/ yes	SDG5 SDG3	Firm, Customer, Society
27	Medical consultation kiosk	Affordable healthcare access, simple setup, local materials.	SME (Start-up)	Pakistan	Healthcare	Product	Infrastructure	yes/yes/yes/ yes	SDG3 SDG10	Firm, Customer, Society
28	Electric motorbikes	Cost-efficient, improved mileage, conventional design.	SME (Start-up)	Pakistan	Transports	Product	Input	yes/yes/yes/ yes	SDG7 SDG11	Firm, Customer, Society
29	Prefab sustainable housing	Low-cost construction, energy-efficient, less material usage.	SME (Start-up)	Pakistan	Housing	Product	Infrastructure	yes/yes/yes/ yes	SDG11 SDG10	Firm, Customer, Society

30	Detachable water filters	Low-cost, efficient filtration, no maintenance.	SME (Start-up)	Pakistan	Water purification	Product	Infrastructure	yes/yes/yes/ yes	SDG6 SDG3	Firm, Customer, Society
31	Low-cost bicycles	Developing low-cost, robust bicycles for low-income populations, adapting high-end models for affordability	SME (Local firm)	Brazil	Transportation	Product	Input	yes/yes/no/	SDG11 SDG10 SDG3	Customer, Society
32	Nanotechnology in cosmetics	85% cost reduction via nanotechnology for safer, more stable cosmetics. Targeting B2B and B2C with custom and standard products	SME (Local firm)	Brazil	Cosmetics	Process	Income	yes/yes/no/	SDG3 SDG9 SDG12	Firm, Society
33	Digital, software-based equipment	Development of digital energy equipment for 25% less cost, retrofitting components for Brazilian market	SME (Local firm)	Brazil	Energy	Product and Process	Input	yes/yes/no/	SDG7 SDG9	Firm, Society
34	3D-printed ventilator valves and CPAP masks	High-speed, cost-effective medical device production using local 3D printing resources	SME (Start-up)	Italy	Healthcare	Product	Infrastructure	yes/yes/no/	SDG3 SDG9	Firm, Society
35	Process innovation in SWH manufacturing	"Simplification, cost reduction in solar water	SME (Local firm)	Brazil	Energy	Process	Input	yes/yes/yes/ yes	SDG7 SDG9, 11 SDG13	Firm, Customer, Society
36	Embrace inflatable low-cost incubator	Embrace, by Stanford University in the USA. Address neonatal mortality. Inexpensive, inflatable for remote areas.	SME (Social enterprise)	India, Nepal	Healthcare	Product	Infrastructure	yes/yes/yes/ yes	SDG3 SDG10	Firm, Customer, Society
37	Clay refrigerator (MittiCool)	Utilizes local materials and traditional skills to create sustainable, affordable products for low-income markets.	SME (Local firm)	India	Appliances	Product	Infrastructure	yes/yes/yes/ yes	SDG7 SDG12	Firm, Customer, Society
38	mOm infant incubator	mOm (initial from UK). Inexpensive, inflatable, provide a cost-effective incubator for low-resource and crisis settings	SME (Start-up)	UK	Healthcare	Product	Infrastructure	yes/yes/yes/ yes	SDG3 SDG10 SDG1	Firm, Customer, Society
39	Wick machine	Automates cotton wick making, traditional method replacement	SME (Local firm)	India	Consumer Products	Product	Input	yes/yes/yes/ yes	SDG8 SDG9	Firm, Customer, Society
40	Cotton stripping machine	A low-cost machine that mechanizes cotton stripping for users who would otherwise rely on manual labor	SME (Local firm)	India	Agriculture	Product	Income	yes/yes/yes/ yes	SDG8 SDG9 SDG5	Firm, Customer, Society
41	Sustainable lighting/ Nuru Energy	Pedal generator, renewable energy, low-cost	SME (Local firm)	USA/Canada	Energy	Product	Infrastructure	yes/yes/yes/ yes	SDG7 SDG10 SDG13	Firm, Customer, Society
42	Solar solutions SELCO	Sustainable energy underserved areas, solar focus and feature-poor offering	SME (Social enterprise)	India	Energy	Business Model	Income	yes/yes/yes/ yes	SDG7 SDG13	Firm, Customer, Society
43	Solar energy solutions BOOND	Affordable, context-adapted, core solar functionality in places where standard energy solutions are often not matched	SME (Local firm)	India	Energy	Product	Infrastructure	yes/yes/yes/ yes	SDG7 SDG9 SDG13	Firm, Customer, Society
44	Affordable Hepatitis B vaccine	Developed cost-effectively, significantly reduced global vaccine prices	SME (Local firm)	India	Biotechnology, Healthcare	Product	Income	yes/yes/yes/ yes	SDG3 SDG10 SDG17	Firm, Customer, Society
45	Bamboo shoots, shift in processing	Adapts traditional methods for larger-scale production using local materials for bamboo shoots	SME (Local firm)	India	Agriculture/Food	Process	Input	yes/no//	SDG2 SDG8 SDG12	Firm, Society
46	Quicker fermentation method (Bishempur type)	Uses modern materials for expedited processing	SME (Grassroots entrepreneurs / Local firm)	India	Agriculture/Food	Process	Input	no///	SDG2 SDG9 SDG12	Firm, Society
47	Packaging and processing of bamboo shoots	Adapts traditional methods for modern business, focusing on packaging and marketing	SME (Local firm)	India	Agriculture/Food	Product and Process	Input	no///	SDG8 SDG12 SDG5	Firm, Society
48	Telemedicine-based primary care	Affordable healthcare via telecommunication	SME (Local firm)	Mexico	Healthcare	Business model	Infrastructure	yes/yes/yes/ yes	SDG3 SDG10	Firm, Customer, Society
49	Biodegradable Toothbrush	Eco-friendly toothbrush made from bamboo and pig hair	SME (Social enterprise)	Taiwan	Hygiene Products	Product	Income	yes/yes/no/	SDG12	Firm, Society

50	Motorized seeder for efficient agriculture	Low-cost, efficient seeder, maximizes seed and fertilizer use, suitable for small-scale Malian farmers	SME (Local firm)	Mali	Agriculture	Product innovation	Input	yes/yes/no/	SDG2 SDG8 SDG12	Firm, Society
51	Pedal generator for energy	Human-powered generator for off-grid areas, affordable energy	SME (Social enterprise)	Rwanda, Kenya, Burundi	Energy	Both	Infrastructure	yes/yes/no/	SDG7 SDG13	Firm, Society
52	Biogas plant using cow dung	Affordable, easy-to-install biogas plant, uses cow dung	SME (Social enterprise)	Kenya	Energy/ Agriculture	Product	Input	yes/yes/yes/ yes	SDG7 SDG13 SDG12	Firm, Customer, Society
53	Sustainable local energy solutions	Utilizing local resources for sustainable energy, like wind turbines	SME (Social enterprise)	East Africa	energy	product	Infrastructure	yes/yes/yes/no	SDG7 SDG9	Firm, Society
54	Simple and ease to repair smartphone	The modularity and repairability features of their smartphones encourage users to keep their devices longer	SME (Social enterprise)	Germany	Electronics	Product	Sufficiency	yes/yes/yes/ yes	SDG12 SDG9 SDG13	Firm, Customer, Society
55	Clothing library	Renting out clothes reduces material consumption and it provides a more economical alternative to buying	SME (Social enterprise)	Switzerland	Fashion	Clothing Library	Sufficiency	yes/yes/yes/ yes	SDG5 SDG12 SDG13	Firm, Customer, Society
56	Online renting of clothing	Customers enjoy a variety of styles without the need to purchase and own multiple items in a cost-effective manner	SME (Social enterprise)	Germany	Fashion	Business Model	Sufficiency	yes/yes/yes/ yes	SDG12 SDG13	Firm, Customer, Society
57	Repair workshops of clothing	By transferring repair knowledge, the business reduces dependency on frequent clothing purchases	SME (Social enterprise)	Germany	Fashion	Business Model	Sufficiency	yes/yes/yes/ yes	SDG4 SDG12 SDG13	Firm, Customer, Society
58	Community-based platform for repair instructions	Contribute to frugality by helping consumers extend the lifespan of their clothes is a cost-effective way	SME (Social enterprise)	Germany	Fashion	Business Model	Sufficiency	yes/yes/yes/ yes	SDG12 SDG9 SDG8 SDG13	Firm, Customer, Society
59	Repair service appliences	Contribute to frugality by helping consumers extend the lifespan of their appliances on cost-effective way	SME (Social enterprise)	Austria	Electronics	Business Model	Sufficiency	yes/yes/yes/ yes	SDG12 SDG13	Firm, Customer, Society
60	Recycle clothing fabric	Using recycled materials (recycled polyester and cotton) . This helps reduce the environmental impact of their products by giving a second life to materials that would otherwise go to waste.	SME (Social enterprise)	France	Fashion	Product	Sufficiency	yes/yes/yes/ yes	SDG12 SDG8 SDG5 SDG13	Firm, Customer, Society
61	Modular smartphone	Fairphone, this businesses approach aligns with frugality by focusing on modularity and repairability	SME (Social enterprise)	Netherlands	Electronics	Product	Sufficiency	yes/yes/yes/ yes	SDG12 SDG9 SDG13	Firm, Customer, Society
62	Biomass Gasification	Affordable electricity production from rice husk; cost-effective, sustainable solution.	SME (Local firm)	India	Energy	Business Model	Infrastructure	yes/yes/yes/ yes	SDG7 SDG13	Firm, Customer, Society
63	Mobile hand sanitizer	Mobile sanitizer for healthcare professionals using basic tools	SME (University + Local firm)	USA	Healthcare	Product	Input	yes/no//	SDG3 SDG7	Firm, Society
64	Modular refrigerator	Modular design allowing customizable refrigerator products for regional markets	SME (Local firm)	Not explicitly stated	Appliances	Product and process	Infrastructure	yes/yes/yes/ yes	SDG9 SDG12 SDG10	Firm, Customer, Society
65	Water-purification process	Cost-effective, sustainable measures in energy and material usage with minimal waste and optimized resource use	SME (Local firm)	United States	Manufacturing	Process	Sufficiency	yes/yes/yes/ yes	SDG12 SDG9 SDG13 SDG7	Firm, Customer, Society
66	Expansion and franchising of schools.	Growth through optimization and reduced reliance on bricolage, with initial minimal resources.	SME (Social enterprise)	Pakistan.	Education.	Business model.	Infrastructure	yes/yes/yes/ yes	SDG4 SDG10	Firm, Customer, Society
67	Bicycle sharing/ subscription service.	Swapfiets provides bicycles on a subscription basis, offering an affordable, convenient, and sustainable transportation option without requiring ownership.	SME (Start-up)	Netherlands	Transportation	Business Model	Sufficiency	yes/yes/yes/ yes	SDG11 SDG12 SDG13	Firm, Customer, Society
68	Solar Powered ATM for rural areas	Solar-powered ATM developed by Vortex Engineering (India), low-cost, energy-efficient, user-friendly ATM	SME (Start-up)	India	Bank Services	Product	Infrastructure	yes/yes/yes/ yes	SDG7	Firm, Customer, Society
69	Electric crane from scrap metal	Utilized waste and scrap materials for practical solutions	SME (Local firm)	Not Specified	Waste Management	Product	Input	yes/yes/yes/no	SDG11 SDG9	Firm, Society

70	Tomato crushing machine	Machine that could crush 200 kg of tomatoes in an hour, facilitating the production of tomato ketchup	SME (Local firm)	Not Specified	Agriculture/ Healthcare	Both	Input	yes/yes/no/	SDG8 SDG12	Firm, Society
71	Energy-efficient cookstoves and ovens	Energy-efficient cookstoves for small-scale bakeries. Frugal due to its energy efficiency and support for low-resource settings.	SME (Social enterprise)	Not Specified	Energy and Food (Bakery).	Product.	Infrastructure	yes/yes/yes/ yes	SDG7 SDG8 SDG12	Firm, Customer, Society
72	Double-pit latrine for waste separation.	A double-pit latrine system, efficient for waste management. Frugal due to its sustainable design and local material use.	SME (Local firm)	Not Specified	Hygiene and Sanitation.	Product.	Infrastructure	yes/yes/yes/ yes	SDG6 SDG3 SDG12	Firm, Customer, Society
73	Affordable laptop designed for children.	Simplified, cost-effective laptop with reduced moving parts for durability and affordability in impoverished contexts.	SME (Social enterprise)	Designed for all users in poverty	Education and Technology.	product	Income	yes/yes/no/	SDG4 SDG9 SDG10	Firm, Society
74	Durable, extendable furniture	Longevity, minimalism	SME (Local firm)	UK	Furniture	Business Model	Sufficiency	yes/yes/yes/ yes	SDG12	Firm, Customer, Society
75	Timeless, high-quality clothing	Long-lasting, ethical fashion	SME (Local firm)	Italy	Apparel	Product	Sufficiency	yes/yes/yes/ yes	SDG 12	Firm, Customer, Society
76	Hydrogen fuel cell-powered vehicle	Sustainability, efficiency	SME (Local firm)	UK	Automotive	Business Model	Sufficiency	yes/yes/yes/ yes	SDG7 SDG9	Firm, Customer, Society
77	'Unprinting' technology	Transforming paper usage, promoting reuse	SME (Local firm)	UK	Office Equipment	Product	Sufficiency	yes/yes/no/	SDG12	Firm, Society
78	Natural wastewater treatment using biotechnology	Innovative, low-cost biotechnological approach integrating microorganisms, plants, and worms for wastewater treatment.	SME (Social enterprise)	Mexico	Water Treatment	Both Product and Process	Infrastructure	yes/yes/yes/ yes	SDG6 SDG14 SDG15 SDG12	Firm, Customer, Society
79	Firefighter Cooling vest	Low-cost, efficient cooling vest, meeting firefighter needs in extreme conditions with resource constraints.	SME (University + Local firm)	Australia	Healthcare/ Emergency Services	Product	Input	yes/yes/yes/ yes	SDG3 SDG8 SDG11 SDG13	Firm, Customer, Society