
1. Capturing frugal innovation: introduction to the *Handbook on Frugal Innovation*

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1. INTRODUCTION

Since the early 2010s, a new perspective of analyzing innovation through a ‘frugality lens’ has emerged, which has led to the introduction of the concept of frugal innovation. The origin of the scholarship on frugal innovation lies in the context of emerging markets, whereby the main idea is to develop products, services and systems that fit these markets’ special needs and requirements and are affordable and have good enough user value to end users who otherwise would remain underserved (Prahalad and Hart, 2002; Soni and Krishnan, 2014; Radjou et al., 2012b; Radjou and Parabhu, 2015; Weyrauch and Herstatt, 2016). The founding scholars of this frugal innovation perspective located the origin of such innovations in the activities and practices of people living in extreme resource-constrained settings (Radjou et al., 2012b). The experiences of living with scarcity, in poverty, with oversight of formal institutions, missing or poor infrastructures and public services and the like could become a source of learning for large corporations for effectively allocating their resources towards ‘doing more (and better) with less’ (Radjou et al., 2012b). Subsequent scholars have argued that, as a practice, frugal innovation can be observed and found across the globe, in both formal and informal economic settings, in both rich and poor countries. Actors involved in frugal innovation can therefore range from multinational corporations introducing and marketing frugal innovations at a regional or global scale to individual innovators who come up with localized frugal solutions that help people to overcome resource constraints in their own neighborhood, community or village.

However, the scholarship on frugal innovation has so far mainly focused on frugal innovations designed and marketed by multinational corporations and smaller (social) enterprises. Rao (2013) listed 30 frugal innovations, but the number of innovations analyzed has risen since then. Well-known examples of frugal innovation include Tata’s Swach water purifier, Tata’s Nano car (which in the end failed), General Electric’s pocket-sized ultrasound device (GE Vscan) and portable electrocardiogram (Mac400), Philips’ automated respiratory rate monitor, M-Kopa’s solar home system, Safaricom’s mobile banking system (M-Pesa), Godrej and Boyce’s Chotukool (frugal refrigerator), Sarah Collins’ Wonderbag, and Unilever’s OMO washing sachets.

What frugal innovations – besides and despite their diversity in origin and context and in actors involved – have in common is that in the design process, the product, service or system is brought back to its bare essential, to what it really should do, while still allowing for a ‘good enough’ functionality and performance in the context for which it is developed. In frugal innovation, manifestations of ‘over-engineering’ are largely removed. This includes, for instance, removing attributes and frills that are added to products and services to increase

functionality and performance but that are rarely used and that are often meant to feed markets with a continuous flow of ‘innovations’ (for example, ‘new’ versions of smartphones) to capture innovation rents. This removal of attributes and frills significantly reduces the costs of the product, service or system, which in turn makes them affordable to end-users who would otherwise remain underserved. Basically, a frugal innovation – which can be a product, service or system – combines cost reduction with maintaining core functionality and safeguarding a ‘good enough’ performance in the context for which it is developed. In this sense, frugal innovation distinguishes itself from other low-cost or resource-constrained innovations. Core functionality and performance may be severely compromised in the latter kinds of innovations. However, the academic discussion of what frugal innovation exactly is and entails and how and in what respects it differs from other innovation definitions and manifestations is still ongoing.

Where frugal innovation initially was picked up by firms as part of their strategies to reach out to new, unsaturated markets in emerging economies and/or as a promising way to combine value capture (profit-making) with value creation (contribute to developmental goals) in these markets (see Howell, 2021; Howell et al., 2018), the idea of frugal innovation soon spilled over into other domains and societal debates. First, some of the innovations initially developed for emerging markets have also found their way into low-income consumer segments in developed markets. These innovations are often referred to as reverse innovations (Govindarajan and Trimble, 2012; Von Zedtwitz et al., 2015). Second, frugal innovation is increasingly seen as a promising way out of vicious cycles of over-engineering with its huge costs, depletion of increasingly scarce resources, and ever-increasing prices involved. For example, the Covid-19 pandemic has been detrimental to societies in many aspects, but it has also raised awareness of how expensive and over-engineered health equipment can be, inhibiting quick, ‘good enough’ diagnostics and treatment of large numbers of patients (Harris et al., 2020). Third, with its underlying idea of frugality, emphasizing the spare use of resources, some scholars have started to explore the relevance of frugal innovation for economic, social and environmental sustainability (Albert, 2019; Herstatt and Tiwari, 2020).

Fourth, and last but not least, among policymakers and scholars, frugal innovation has started to offer a wider lens on the origins of innovations and the actors who are actually involved in the design, production, and diffusion of innovations. Although low-tech innovations have always existed and incremental innovation has been recognized since the early 1980s (Dewar and Dutton, 1986; Munson and Pelz, 1979), innovation has been mostly defined and perceived as high-tech and often costly solutions that originate from large firms’ research and development departments and university laboratories, mostly located in high-income and industrialized countries. Behind this perception is an implicit assumption that innovation can only take place in rich capital (both material, technological, financial and human) contexts. Frugal innovation broadens the perspective on low-cost innovations in low-income settings and innovation practices that originate from and take place at a grassroots level. At this level local innovators, farmers, entrepreneurs, and ordinary citizens develop low-cost and context-specific solutions to overcome local constraints, be they institutional, technological or social, and often not meant to commercialize at a larger scale. These innovation practices – to be found in both low-income and high-income settings across the globe – have so far largely remained ‘below the radar’ of mainstream innovation studies (Kaplinsky, 2011), but with a frugal innovation lens, they increasingly attract attention (Bhaduri, 2016; Bhaduri and Talat, 2020; Leliveld and Knorringa, 2018). One example is a clay fridge, the Mitticool, invented

by school dropout Mansukhbhai Prajapati from Gujarat, India (Patel et al., 2021). The fridge does not need electricity and naturally keeps food items fresh for several days. It costs less than US\$100.¹

Alongside the emerging societal interest, frugal innovation has only attracted attention and gained momentum as an academic field of interest quite recently. In the past two decades, an emerging strand of academic literature has started to document and investigate frugal innovations across the globe to better understand what frugal innovation is, who is involved and why, and what its societal relevance could be. Despite this growing interest and emerging body of academic literature on the topic, both Hossain (2018) and Hindocha et al. (2021) observe that frugal innovation still has difficulties to become an academic field of interest in itself owing to the wide range of partly overlapping definitions and conceptualizations of the same manifestation. The current academic debate on frugal innovation is still in its infancy, but it is precisely this infancy which offers an excellent opportunity for a handbook on frugal innovation to explore in-depth this new innovation theme and explore directions for future research. In the fast-growing body of literature, frugal innovation is sometimes presented as an alternative innovation paradigm that can profoundly change the ideas of what innovation (practices) entails or could be. This requires us to take a fresh look at the technologies, sources of knowledge, the business models, the role of various actors and the coalitions involved, and the governance, institutional and policy environment in which innovation takes place.

But how valid are these claims? Does the idea of frugal innovation have the potential to change our perspectives on innovation in these directions? There is a need for a much deeper exploration and analytical understanding of what frugal innovation is and what it entails before we can answer this question. ‘Capturing frugal innovation’ is, therefore, an appropriate title for this chapter, since it appeals to the notion of exploration and to attempts to better understand and question a phenomenon that has increasingly caught the interest of scholars.

What the authors in this book have in common is that they want to contribute to a better understanding of frugal innovation, what it is, what it entails, and whether it can change the ideas of what innovation is and should be for. Conceivably, a multidisciplinary perspective is required to arrive at a better understanding. The authors in this book represent various disciplines, including innovation studies, history, economics and business, development studies, anthropology, industrial design and technology studies, and philosophy and ethics. In our view, the chapters represent a good sample of current discussions and debates on frugal innovation. We preferred critical analytical contributions above prescriptive ones: contributions that bring in new ideas and perspectives over review or overview articles. Although frugal innovation can start from “the standard” innovation perspectives, it definitively goes beyond and includes attention to innovation practices in other parts of the world and beyond corporates. For this *Handbook*, we have therefore decided to present (case) studies on frugal innovation across the globe. The juxtaposition of chapters in this handbook aims to debate and have a dialogue between scholars, both within and beyond frugal innovation studies, across geographical regions.

The purpose of this introductory chapter is to position the *Handbook* in the current academic debate on frugal innovation – not to replicate and present a comprehensive and exhaustive history of academic thought on frugal innovation – for which the reader is referred to several literature reviews and bibliometric studies and (edited) volumes that have been published between 2014 and 2021, which together provide a comprehensive view on the current state of the art in frugal innovation scholarship.² This chapter is further structured as follows. Section

1.2 brings out the diverse thematic areas which inform the origins and concepts of frugal innovation. Section 1.3 presents developments that have sparked academic interest in it. Section 1.4 will go into the current academic debate on frugal innovation, focusing on the question of how does frugal innovation differ from other forms of innovation, and how this shapes the current academic debate and leads to fields of further investigation. From this, we distil academic investigative themes that have guided the structure and contents of this book, which will be explained in Section 1.5.

1.2. ORIGINS AND RISE OF FRUGAL INNOVATION

Frugal innovation is a concept that only recently attracted attention from academic scholars and is still in a state of infancy from a theoretical perspective (Hossain, 2018). While innovation studies have become a well-developed and established field of academic studies, the addition of the adjective ‘frugal’ to ‘innovation’ has led to new and an increasing number of publications which aims to explain and understand its conception, development, diffusion and outcomes (Hossain, 2020). This section describes the introduction of frugal(ity) in academic debates on innovation.

1.2.1. Understandings of Frugal and Frugality

To the reader, innovation will probably be a familiar concept; the terms ‘frugal’ or ‘frugality’ might sound less familiar, though, in particular to those living outside Anglophone parts of the world. Colloquially – in today’s speak – ‘frugal’ mostly refers to sparing, thrifty, or economical, mainly in regard to the use of resources. Etymologically, the word frugal traces its roots back to the 16th century and is derived from the Latin word *frux*, meaning ‘fruit’ or ‘value’ (Jain and Bhaduri, 2021).

Related is the term frugality, which refers to the quality of being frugal, sparing, prudent or economical in the use and consumption of resources, and avoiding waste, lavishness, luxury or extravagance (Hossain, 2018; Onsongo and Knorringa, 2020). Throughout history, philosophers and religious leaders have mentioned and promoted frugality, whereby frugality is framed in terms of a virtue (simplicity, temperance, self-restraint, moderation) that could help to re-direct the relationship to oneself and with others in a direction that would benefit society as a whole (Bouckaert et al., 2011; Jain and Bhaduri, 2021). People who promoted frugality are Lao Tze, Buddha, Socrates, Plato, Epicurus, Jesus, Mohammed, More, Spinoza, Rousseau, Kant and Gandhi. Their arguments in support of frugality can be classified as either religious (simple living brings you closer to God), moral (it fosters virtue), or prudential (it will make you happier) (Westacott, 2018).

The connection of frugality to prosperity and material welfare is explicitly made in the works of Benjamin Franklin, Adam Smith, Alfred Marshall and Max Weber, who advocated that private frugality as a virtuous way of accumulating capital by saving would increase national wealth and offset wastefulness (BurrIDGE, 2012; Jain and Bhaduri, 2021; Onsongo and Knorringa, 2020). Similar connotations can be found in neo-Confucianism, in which frugality – in combination with hard work – is seen as a way to accumulate resources that would benefit the prosperity of one’s family (Onsongo and Knorringa, 2020). In India, the Buddhist interpretation of frugality refers to being careful with limited resources to get ‘more out of little’. In

contrast, in the former Soviet Union and in countries which were under its influence, frugality triggered the connotation with the existence of a ‘repair society’, in which the preservation and prolonged use of resources and the transmission of repair skills and practices rose from an economic system that provided insufficient and low-quality goods of which the consumption was under state regulation (Gerasimova and Chuikina, 2009). More recently, adoption and expressions of frugality as a virtue can be found among environmentalists and minimalists. Environmentalists see frugality as a way forward towards achieving sustainability through, for example, less consumption, less commuting, fewer carbon emissions, less wastefulness, and less carelessness. Minimalists think frugality can help you to become mindful of how you spend your money and time.

Although the previous paragraph might suggest otherwise, the meaning and the role of frugality in daily life practices are not by definition informed by choice. The majority of the world population lives and works under conditions of severe resource constraints (be it technological, institutional, social and/or economic) – either absolute or socially constructed (Pansera, 2018) – which prevents people from having the freedom to live a life they have reason to value (Sen, 1999). Under these conditions, which include poverty, war, socially constructed scarcities for specific groups in society, and environmental degradation, living frugally becomes an involuntary act; applying frugality in daily life becomes necessary to survive. Under these circumstances, frugality needs to be much more understood in terms of ‘bricolage’, (creative) ‘improvisation’, and ‘to make ends meet’, and loses in many cases its positive connotation of being a virtue that could help one live a better and meaningful life (Pansera, 2018; Onsongo and Knorringa, 2020). This is in contrast to contexts where resources are (perceived to be) abundant, mostly found in affluent industrialized countries in the West. Actually, in the era of consumerism that followed the Second World War in this part of the world, frugality as a virtue that informs choices in how to live a meaningful life almost completely disappeared below the radar (Jain and Bhaduri, 2021; Onsongo and Knorringa, 2020). Despite early warnings (Meadows et al., 1972), it is only quite recently, with the increased awareness of the depletion of non-renewable natural resources and its detrimental effects on people and the planet, that frugality – also in the West – has come more to the forefront again. Still, today, living a frugal life in this part of the world is mostly seen as an act of voluntarism, not driven by sheer necessity. Hence, in this context, frugal and frugality bear a much more positive connotation than in many other parts across the globe.

In sum, throughout history and across philosophies, religions and human practices, frugal and frugality connect to notions of sparing, simplicity, temperance, and to notions of circularity (repair) and sustainability in relation to the use of (scarce) resources. Whether frugal is to be perceived as a virtue depends a lot on the conditions in which people live and work. Under severe resource constraints, living frugally becomes an involuntary action in order to survive. In affluent contexts, a frugal life is still largely considered to be a voluntary act, informed by religious or philosophical notions on how to live a good life or by concerns about the degradation of the natural environment and the role of humans in this. It is important to distinguish between the different connotations that frugal and frugality have across the globe, as it also reflects in the academic and societal debate on frugal innovation. In the next subsection, we go into more detail on how frugal and frugality became linked to innovation.

1.2.2. Linking Frugal to Innovation

So, while frugality has a long history, its linkage to the concept of and scholarship on innovation is of much more recent date. Hossain (2018) states that the origin of the concept of frugal innovation is not clearly known, nor is the origin clearly mentioned or to be found in the frugal innovation literature. The earliest academic journal paper on frugal innovation that Hossain (2018) could trace in the Web of Science database was by Zeschky et al. (2011). One year earlier, in 2010, *The Economist* coined the concept in the popular press (“First break all the rules”, 17 April 2010). Some scholars (Hossain, 2018; Radjou et al., 2012a) trace the origin of the concept back to ‘frugal engineering’, introduced in 2006 by Carlos Ghosn, the Chairman and CEO of the Renault-Nissan Alliance. Ghosn started promoting the idea that over-engineered products by Western companies are no longer sustainable – both for economic and environmental reasons. His message was that Western car manufacturers need to make simplicity a key tenet of their innovation process by developing “good enough” offerings that deliver significant value for money to cost-conscious consumers. Ghosn proclaimed that Western automakers must sacrifice the “bigger is better” Research & Development model and adapt to ‘frugal engineering’ (Radjou et al., 2012a).³ Jain and Bhaduri (2021) refer to Richard Schonberger’s article ‘Frugal manufacturing’ in the *Harvard Business Review* in 1987 (Schonberger, 1987). In this article, Schonberger makes a pioneering attempt to conceptualize frugality in the context of a manufacturing process, depicting a scenario for a frugal approach in manufacturing which Schonberger calls “mini factories”.

The use of the word ‘frugal’ in ‘frugal engineering’ and ‘frugal manufacturing’ does reflect some of the colloquial meanings of frugal, but frugal as used in ‘frugal innovation’ was introduced in a different way, namely by referring to *Jugaad*, a Hindi word which in India refers to fixing something quickly with makeshift parts to get the job done. In India, *Jugaad* is not by definition perceived as a positive notion. For instance, the urban middle class does not want to be identified with *Jugaad*, which is considered to be something for the poor, often associated with people who are lazy or do not put a lot of time or effort into their work. Yet, Radjou et al. (2012b) gave *Jugaad* a positive connotation and linked it to innovation, referring to *Jugaad* as an innovative fix to any problem in a resourceful, flexible and intelligent way. Intelligence in this context “isn’t about seeking sophistication or perfection by over-engineering products, but rather about developing a ‘good-enough’ solution that gets the job done” (Radjou et al., 2012b: 109).⁴ This positive notion of ‘*Jugaad* innovation’ has been introduced by Radjou et al. (2012b) in western innovation and product management and in business literature to show western companies how they can adopt *Jugaad* innovation to succeed in a hypercompetitive world in which companies originating from emerging markets as India, China and Brazil have become increasingly successful. Instead of relying on the standard formula, that is, expensive R&D projects and highly-structured innovation processes that have sustained innovation practices for decades, Radjou et al. (2012b) argue that *Jugaad* innovation can offer a new approach to more frugal and flexible innovation. The key principles of this approach are: see opportunity in adversity, do more with less, think and act flexibly, keep it simple, include the margin, and follow your heart (Radjou et al., 2012b).

In 2015, Radjou and Prabhu published a follow-up book, putting frugal innovation center stage, therewith putting more emphasis on ‘doing *better* with less’ than ‘doing *more* with less’. Again, their message was directed towards firms in mature markets, arguing that in times of recession and income stagnation in western economies, middle-class consumers are seeking

cheaper products and better value. In order to adapt supply to this changing demand, firms are required to provide products and services at lower costs while maintaining or even improving user value. This will make companies better able to meet the untapped needs of low-income customers. To innovate frugally in every aspect of business, from engineering to supply chains and research and development departments, will enable companies to reach out not only to low-income consumers in high-income countries but also to income-poor consumers at the so-called Base of the Pyramid (Prahalad and Hart, 2002) who live under severe resource constraints in low-income countries. Frugal innovations could help to overcome some of these constraints, in particular in areas such as energy, water and sanitation, health, agriculture, and household utensils.

In sum, the concept of frugal innovation has its roots in the 2010s in the western-based innovation and business management literature. In retrospect, though, the practice of frugal innovation has been a long tradition in many parts of the world other than Europe and the USA. Kaplinsky (2011) observes that in the literature on informal economies in poor countries, it has been shown for decades that small-scale and locally owned firms are key providers of tailor-made products and services for low-income consumers. In these informal economies, not only do the end-users – the consumers – live and work in a resource-constrained environment, but the innovators and entrepreneurs do as well, and they are often as poor as the customers they aim to serve. Their products and services are, therefore, the result of long-term experiments and innovative practices in which frugality is key, given the resource-constrained environments in which such practices take place. Moreover, many if not most of these incremental innovations are carried out by individuals, households, and communities – i.e., not by firms – and are not driven by commercial incentives but part of people’s bricolage and survival and livelihood strategies (Bhaduri, 2016). In these contexts, frugal innovations are the result of the cumulative effect of implementing small-scale ideas under severe resource constraints over prolonged periods of time, which includes processes of experimentation and intergenerational learning (Bhaduri, 2016), and adoption, adaptation, appropriation, and transformation of products, services and systems. These processes do not only include scientific and technological products and systems, but may also aim to overcome institutional, organizational, social, and political constraints or voids (Bhatti, 2012; Bhatti et al., 2018). Apart from an intense span of attention for these sorts of innovation practices in the 1970s and early 1980s due to the ‘appropriate technology movement’ inspired by Schumacher’s ‘Small is Beautiful’ (Schumacher, 1973), these bottom-up frugal innovations by the poor themselves have largely remained ‘below the radar’ of mainstream innovation studies (Bhaduri, 2016; Chataway et al., 2014; Kaplinsky, 2011; Leliveld and Knorringa, 2018).

Historically, frugal innovation has not been new to industrialized countries either. In fact, there was a return to the principles of the industrial revolution, during which wealth creation took place by focusing on industry and frugality, something that Adam Smith pointed out in his *Enquiry into the Wealth of Nations*. Bhatti (2012) shows that frugal innovation has also been manifest in 19th and 20th century Western Europe, for example, in times of recession and war. He presents illustrative examples of frugal innovations in the garment and furniture industry in the United Kingdom during the Second World War. Sluiter (2017) points out that also the Greeks and Romans were very much intrigued about finding appropriate and affordable solutions for their daily problems. Still, as Jain and Badhuri (2021) observe, frugality as a philosophical notion or virtue disappeared below the radar in the 19th and 20th centuries in western societies. Referring to Trippett (1980) and Leach (2011), they argue that one of the

reasons for the downfall of the concept of frugality in this era in western countries could be the rise of ‘consumerism’ which came with the Industrial Revolution and the unprecedented increase in wealth that resulted from it. It is in this era that the concerns for frugality in western countries largely remained confined to a narrow understanding of thrift, and the more philosophical underpinning of frugality was lost in most domains of life (Jain and Bhaduri, 2021).

1.3. GLOBAL AND REGIONAL DEVELOPMENTS THAT HAVE SPURRED THE INTEREST IN FRUGAL INNOVATION

The previous section investigated how and when the idea of frugal(ity) became linked with the concept of innovation. Since then, the interest in frugal innovation has grown substantially, both among academics, practitioners, and policymakers. What becomes clear is that frugal innovation apparently appeals to a wide variety of societal actors for many different reasons. Both economic, social, technological, developmental and environmental concerns and opportunities play a role. This section goes into more detail on why there is such a growing interest in frugal innovation since the introduction of the concept in 2010. This will contribute to a better understanding of what the current academic debate on frugal innovation is about (see Section 1.4), and it provides further information on the choices that have been made on the topics and themes that are presented in this handbook (see Section 1.5).

The main reason why frugal innovation attracts the attention of academics, policymakers and practitioners (including designers, engineers, and entrepreneurs) is the search for an alternative innovation paradigm that has the potential to contribute to innovative solutions to address some of the major problems that people across the globe currently experience and are struggling with. Whether frugal innovation has this potential is still a major issue of contention in the emerging academic literature on frugal innovation (Knorringa and Leliveld, 2018; McMurray et al., 2021; Meagher, 2018; Pansera, 2018), but the perception that frugal innovation has this potential has strongly gained a foothold in the past decade, among actors in both high-, middle- and low-income countries and regions. Several interrelated global and regional developments have fed and spurred this perception.

First, falling structural economic growth rates in industrialized countries, in particular during the last decades, provoked explanations on why this happens (Bloom et al., 2020). Many western-based (multi)national enterprises producing and selling premium products and services to high-income customers have experienced that their innovation processes have become less efficient over time. With the aim of reducing the inherent uncertainty of innovation processes, innovative firms manage these processes through standardization and installing routine procedures (Baumol, 2002). This can become a vicious cycle; more management control requires more financial resources as input in order to generate more innovation output. As a result, new products, processes and systems become over-engineered and (have to be) sold at high premium prices to (high-income) consumers. For example, the rising R&D expenditures by the pharmaceutical industry are increasingly resulting in fewer new drugs being launched and those that are need to be sold at very high prices in order to recoup the increasing R&D spending (Cockburn, 2007; Scannell et al., 2012). Christensen (1997) has developed a theory of disruptive innovation in which he shows that innovative firms in high-income markets ignore customers that aim for less over-engineered products at lower prices as their profitability will not be increased by serving these clients. Serving these

customers provides opportunities for disrupting competitors. These disruptors have the potential not only to serve existing customers but also include customers that were not in the market before. Hart and Christensen (2002) link the disruptive theory to serving low-income customers at the Bottom-of-the-Pyramid and thereby combine corporate growth with doing good.

This emerging discourse in innovation management and business organization literature on the so-called Bottom (later Base) of Pyramid (BoP) in the early 2000s has been very influential in these explorations. It argues that corporate business can find fortune by serving the BoP, those living on less than two US dollars a day, an estimated four billion people worldwide, who would constitute a mega and still unsaturated market of ‘micro’ consumers and are underserved by existing products and services (Prahalad and Hart, 2002). However, to serve the markets successfully, different kinds of products and services are required. Because the low-income setting often involves institutional and resource constraints – such as limited capital resources, lack of basic provisions, weak infrastructure or poor governance – innovation has to follow a different path than the capital-intensive research and development process common in Western markets (Kaplinsky, 2011; Bhatti, 2012). This requires a rethinking of technology development, the entire production processes and business models, as well as innovation cycles (Rao, 2013). It is not surprising to observe then that frugal innovation, which involves (re)designing products, services or systems to significantly cut costs without sacrificing user value, is increasingly seen by companies as a way to reach a mass customer base, especially in low-income settings (Bhatti, 2012; Tiwari and Herstatt, 2012; Rao, 2013). In addition, arguments can be found in the literature that the frugal products, services and systems that are originally designed and produced for low-income markets in Asia, Latin America and Africa could also appeal to cost-conscious consumers in Europe and North America (Govindarajan and Ramamurti, 2011; Grover et al., 2014; Radjou and Prabhu, 2015). In this sense, frugal innovation could lead to reverse innovation (Agarwal and Brem, 2012; Hadengue et al., 2017; Immelt et al., 2009; Zeschky et al., 2011), whereby frugal innovations are first introduced into low-income markets and, if successful, are also introduced into middle and high-income markets.⁵ Firms from high-income countries face fierce competition at the BoP because they have to compete with frugal innovation-oriented firms from China and India, for whom the home market has been a learning ground to provide frugal products and services to low-income people.

Partly as a result of the first development and aggravated by the global financial crisis between 2007 and 2009, government budgets in the USA and EU countries were hit hard. This impacted a second development, namely a squeeze between structural rising public sector expenditures to deal with grand challenges. These challenges include demographic changes (ageing of the population putting a lot of pressure on the health sector), increased demand for security and environmental concerns, and fiscal wisdom. This has spurred a search for innovative solutions in public provisions that require less huge investments and can help to overcome resource constraints in, for instance, the health sector. Apart from a shift of attention to the role of local innovators and entrepreneurs in providing public services and infrastructures, frugal innovation has been explored as a possible way out of the squeeze. In 2016, the EU commissioned a study on the potential of frugal innovation for Europe. One of the main conclusions was that frugal innovation asks for the involvement of different actors with a broader range of activities than traditional technology-developing companies (European Commission, 2017).

A third development that has spurred the interest for frugal innovation is the absence of effective working governments and technological infrastructure in many low-income

countries, which impedes sufficient, affordable and accessible public goods and services that can foster and support economic growth, transformation and human development. In many low-income countries, governments generally lack the means and, in some cases, the political will to provide infrastructures and public goods and services such as safe drinking water, energy, health facilities and adequate housing for the majority of people. Designing and providing these services in a frugal way has increasingly become a terrain of multinational companies, social enterprises, and (inter)national NGOs. This trend has been further spurred in these countries by a policy shift away from state direction in innovation and industry towards an emphasis on private sector development, which, among other things, entails a valorization of private enterprise, market efficiency, entrepreneurship and the conviction that markets can work for the poor (Arora and Romijn, 2012; Dolan and Roll, 2013; Schulpen and Gibbon, 2002; Blowfield and Dolan, 2014).

The above three developments spurred a fourth development, namely growing attention for innovation practices of (individual-) innovators and entrepreneurs who (have to) work under resource-constrained conditions.⁶ Differences between high- and low-income settings may exist when it comes to the degree to which these individual innovators are confronted with resource constraints. But they share a focus on experimentation, intergenerational learning, improvisation and adaptability. In combination with their good knowledge about local conditions and constraints and the needs of local users, they have the potential to come up with good enough, frugal solutions that will help end-users to overcome (part of) their resource constraints. These innovators and entrepreneurs have not only become a source of inspiration on how to innovate under resource constraints and innovate more frugally, but their knowledge of local conditions and innovative capability are also increasingly considered by larger firms as a pivotal input to designing and selling successful frugal innovations. Therewith the development and extension of Global Value Chains reshaped global production and trade and afforded a new role to (low-income) innovators, entrepreneurs and consumers (Kaplinsky and Farooki, 2010; Gereffi, 2014). The trade collapse in 2008 further accelerated the shift in end markets from the North to the South, challenging the dominance of Western types of innovation (Gereffi, 2014). In the most optimistic scenario, local innovators and entrepreneurs function as co-creators of innovation (Beugré, 2015; Chironga et al., 2011) or become part of the entrepreneurial model or value chain (see Dolan and Roll, 2013; Meagher, 2018; Peša 2017, 2018). Radjou (2009) refers in this respect to ‘polycentric innovation’ in which multiple actors are supposed to co-create and collaborate. So far, when it comes to frugal innovation, studies on how this works out in practice are scarce. Some studies show it can work (see Habiyaemye, 2020; van der Merwe et al., 2020); others are cautious and point out the inherent conflicts of interest that may exist among the various actors (Dolan and Roll, 2013; Meagher, 2018). Grobbelaar et al. (2017) (see also Chapter 26 in this *Handbook*) indicate in their study on co-creation in university-driven inclusive innovations the complexity of the subject matter and the urgent need for a ‘system of innovation components’ approach to enhance our understanding of inclusive innovation projects and to develop appropriate methodologies for measuring their impacts.

A fifth development that underlies the increased attention for frugal innovation is the increasingly widespread awareness of the ultimate global consequences of existing production and economic models in terms of environmental pollution and resource depletion, leading to an urgent need to invest in a global green transformation with low carbon footprints, and production and consumption patterns based more systematically on circularity and usage

instead of relying on mass production, ownership and waste creation. Globally, discussion on degrowth and other alternative thinking models on what ‘development’ actually is and entails has started to flourish (see, for instance, Asara et al., 2015; Dartnell and Kish, 2021; Kerschner et al., 2018; Raworth, 2017; Weiss and Cattaneo, 2017). Underneath the current production and economic models that dominate the global economy is an innovation model and thinking that emphasizes value capture more than value creation. Frugal innovation is perceived as an alternative innovation and business model that could better balance value capture and value creation (Howell, 2021) and, therefore, could contribute to achieving more sustainable societies (Hossain, 2021; Hossain et al., 2021; Levänen et al., 2016; Rosca et al., 2017). In addition, the awareness of climate change largely explains the call for frugality in western societies, which is mainly driven by environmental concerns, e.g., recycling, energy reduction, solid waste management, and minimizing carbon footprints. Contemporary frugality movements such as, for example, the ‘voluntary simplicity’ movement’ (Bouckaert et al., 2011), ‘ethical consumerism’ and the POC21 Innovation Community combine more traditional virtues with environmentalism. A contemporary translation of frugality can also be found in discussions on circular economies, renewable energy and the energy transition and among maker and prosumer movements at various places across the globe (Prabhu, 2017; Herstatt and Tiwari, 2020).

While the previous five developments explain to a large extent the emerging attention for frugal innovation, the potential of frugal innovation to become a significant innovation manifestation is also very much related to a sixth development, namely the fast-changing technological developments in the last two decades. The Fourth Industrial Revolution (4IR) is broadly defined as the current and developing environment in which disruptive technologies and trends, such as the Internet of Things (IoT), robotics, virtual reality (VR) and artificial intelligence (AI), are changing the way we live and work (Schwab, 2017), and the preceding or underlying digital revolution which has led to ICT as a new General Purpose Technology as engines of economic growth (Bresnahan and Trajtenberg, 1995; Perez, 2010).

How and to what extent the Fourth Industrial Revolution technologies could be conducive to frugal innovation needs further investigation (Agarwal et al., 2021; Leliveld and Knorringa, 2018; Altamirano and van Beers, 2018). The use and application of the new technologies could facilitate the emergence of frugal innovations and business models that enable companies to enter markets that remained unserved before, in particular, because the use and application of digital technologies can contribute to substantial cost reduction while maintaining or even improving functionality and performance. In light of the sustainability discourse, the new technologies can lead to frugal innovations that contribute to the realization of more environmentally sustainable products, services or systems by making innovations less reliant on or making more efficient use of scarce resources, also introducing ideas of circularity and durability into the product, service or system design (Prabhu, 2017; Radjou and Prabhu, 2015). And where governments from low-income countries have for a long time chosen to import technological solutions and innovations from rich countries, in many cases to no avail (Fu et al., 2011). Today’s global diffusion of digital technologies is said to facilitate access, and lower entry barriers for local innovators and entrepreneurs could have an enabling role in developing people’s frugal innovation capabilities in low-income countries (Ahuja and Chan, 2021; Bhatti et al., 2017; Pandit et al., 2018).

When it comes to frugal innovation, this could go in two directions. First, opensource software and opensource communities could spur the development of frugal (versions of)

digital technologies (or Fourth Industrial Revolution technologies) by actors in low-income countries (or resource-constrained actors in high-income countries) and, second, digital technologies are used for the development of frugal innovations that can be used for local development or to overcome resource constraints. Maric et al. (2016) present this argument for 3D printers; they stress the dual nature of 3D printers as a frugal innovation itself and as an enabler for frugal innovation. Prabhu (2017) and Radjou and Prabhu (2015) also hint at the potential of some digital technologies and concepts – such as 3D printers, maker spaces and WhatsApp – as being frugal innovations in themselves. Digital infrastructures, such as the well-known example of the mobile payment service M-Pesa, could also provide infrastructure and enable new business models that allow for frugal product and service deliveries in resource-constrained communities, such as the M-Kopa Solar (Rastogi, 2018; Howell et al., 2018). With a case study on a frugal digital health platform, Ahuja and Chan (2021) show that by following principles of frugal innovation, digital platforms can have positive eco-system-wide impacts. The application of sensor technology for the development of frugal weather stations is another example of how digital technologies could enable frugal innovations (Van de Giesen et al., 2014). Yet, reality shows that new dependencies arise, namely on Big Tech firms (mainly from the USA and China), and that core innovation Hubs remain concentrated in the high-income regions of the world (Sturgeon, 2021; UNCTAD, 2019). Digital exclusion may take place not only because of unequal access to technologies and infrastructure but also in terms of skills needed for software developed by Big Tech firms. These realities could reduce the opportunities for innovators in low-income settings to experiment with new technologies such that frugal innovations can be the result.

Lastly, and more recently, the Covid-19 pandemic has further spurred the attention for frugal innovation. The pandemic caused worldwide resource constraints, either absolute or socially constructed, and this has spurred a wide range of frugal innovations in the health sector as an answer to severe resource constraints caused by the pandemic (see Harris et al., 2020; Vescei et al., 2021; Corsini et al., 2021), as well as thoughts about the post-corona society (see Herstatt and Tiwari, 2020; Dartnell and Kish, 2021).

In sum, from a societal perspective, the interest for frugal innovation is not just a one-time single issue that is proclaimed and captured by one specific group of interest. Generally speaking, from a societal perspective, one could argue that the growing interest in frugal innovation stems from a quest for a new innovation paradigm that could contribute to the embarking on a different economic and human development trajectory, both in low-, middle- and high-income countries. Frugal innovation is ascribed transformational potential for the better, in areas such as business, sustainability, wealth creation, poverty alleviation, social and economic inclusion, and human development. Whether it can live up to these expectations is still a matter of debate, and needs much more theoretical and empirical investigation (Pansera, 2018; Hindocha et al., 2021; Knorrington et al., 2016; McMurray et al., 2021), which brings us to some further observation on the academic debate on frugal innovation in the next section.

1.4. SOME FURTHER OBSERVATIONS ON THE ACADEMIC SCHOLARSHIP ON FRUGAL INNOVATION

In the previous sections, it has been shown that frugal innovation has attracted increased interest from academic scholars and is brought into relation with several recent societal devel-

opments. Between 2010 and 2020, the number of publications on frugal innovations has risen sharply (see for recent bibliometric studies, Dabić et al., 2022; D'Angelo and Magnusson, 2021; Melnikova and Gilsanz, 2022). Whereas the academic interest initially came from scholars involved in product management and business studies, the topic soon spread like an oil slick across other disciplines, including innovation studies, development studies, anthropology, law and governance, political economy, sustainability studies, decision-making theories, and design and engineering studies. Sector-wise, energy, water, health, agriculture, transport, the building environment, education, and technology have been the focus of the majority of the studies from different disciplinary and topical angles (Hossain, 2020; Rosca et al., 2017).

From the existing body of literature on frugal innovation studies, it becomes clear that a key issue in the academic debate on frugal innovation is still its conceptualization, which also problematizes the development of an adequate conceptual and theoretical framework. Frugal innovation has gained rising popularity in various sectors and disciplines, resulting in multiple and diverse definitions that often lack a theoretical foundation (Hindocha et al., 2021). Up to now, there is no standard definition of frugal innovation, which is also due to the use of partly overlapping concepts and terminologies. Concepts such as Jugaad innovation, reverse innovation, Gandhian innovation, responsible innovation, inclusive innovation, disruptive innovation, resource-constrained innovation, cost innovation, grassroots innovation, and good-enough innovation, many of these again having plural meanings, complicate the canvas. Often, frugal innovation and these terminologies are used interchangeably owing to their similar premises despite their different backgrounds (Agarwal and Brem, 2017; Brem and Wolfram, 2014; Bhatti, 2012; George et al., 2012; Hindocha et al., 2021; Hossain, 2018, 2020; Zeschky et al., 2014).

On the topic of definition, Pisoni et al. (2018) identify three generations of definitions. The first generation started to refer to the product-based features of frugal innovation and highlight the characteristics of frugal products and services, such as low price, compact design, limited use of raw materials or reuse of existing components, ease of use, and cutting-edge technology to achieve lower costs. A second generation went beyond this and underlines that frugal innovation refers to products and services that are specifically developed in or for resource-constrained environments to serve people at the BoP. In this line of thought, there are also those who define frugal innovation in terms of a process, for example, a means and end to do more or better with less for more people (Radjou and Prabhu, 2015) or a design innovation process that considers the needs and context of citizens in low-income countries (Basu et al., 2013). A third generation is returning again to the basic characteristics, such as the widely used definition by Weyrauch and Herstatt (2016), who identify three criteria to distinguish frugal innovations from other innovations: substantial cost reduction, concentration on core functionalities, and optimized performance level. Agarwal et al. (2017) also fit in this generation by identifying three fundamental dimensions of constraint-based innovation: cost-effectiveness, ease-of-use, and prescriptive variables, which for example, relate to affordability, inclusion, and poverty alleviation and/or sustainable characteristics of frugal innovations. According to Pisoni et al. (2018), the conceptualization of frugal innovation in terms of its major features makes it at least possible to arrive at an operational definition of frugal innovation that can be used in empirical research and data collection. It also abstains from adding normative connotations to the concept, which leaves open the empirical question of whether frugal innovations are as inclusive, sustainable or transformational as is advocated in part of the popular literature on frugal innovation. Yet, it needs to be taken into account that multiple disciplines

are involved in the study of frugal innovation, and therefore multiple interpretations may still exist on the terms, criteria, and concepts to be used to define frugal innovation (see Hindocha et al. 2021, Table 2, pp. 651–653).

Still, while an operational definition with product, service or system characteristics can help us to collect data and conduct empirical research, it is well-known from the innovation literature that the concept of innovation is not only referring to an outcome and end product. Innovation is understood as a process, a practice or an approach as well, and we should definitely not lose sight of this in the academic scholarship in frugal innovation because it can help to further and better understand what frugal innovation is and entails. It has been noted earlier how the founding scholars of frugal innovations located the origin of frugal innovation in the activities and practices of people living in extreme resource-constrained settings (Radjou et al., 2012b). The lived experiences with scarcity and ‘institutional void’, according to many, could become a source of learning for large corporations to effectively allocate their resources towards ‘doing more’ (and better), with ‘less’. Conceivably, ‘resource constraint’ here does not only refer to constraints in the access and ownership of tangible material resources, it also includes restrictive access to intangible resources such as information and knowledge networks important for innovation. This is perhaps expected, given that for people living with extreme resource constraints, their lack of education and social status often exclude them from the more formalized structures of information and knowledge sharing. Since innovations primarily are a cognitive process involving search, experimentation and trial-and-error under uncertainty, it is pertinent to ask how these innovative steps are carried out under such extreme constraints of information and knowledge. Decision theory research in the tradition of bounded rationality, emphasizing the importance of heuristics, improvisations and judgment of the so-called journeymen of experiences, could be relevant to take on board (Keirandish and Mousavi, 2018).

Frugality here refers to the use of such smart cognitive devices of heuristics and ‘rule of thumb’ (as opposed to structured algorithms and decision protocols) gained through one’s context-specific experiences as users or makers of technologies. In putting forward the argument for ‘frugal manufacturing,’ Richard Schonberger points out how such user’s knowledge can avoid ‘over-engineering’ and create space for more ‘judicious’ patterns and degrees of automation in an industrial unit (Schonberger, 1987). Back in the history of industrialization, makers and users of technologies were indeed identified as a major source of technological change by Adam Smith. With the progressive division of labor, the worker got confined to performing a few simple operations to become, in Smith’s words, ‘stupid’ and ‘ignorant’, and who has “no occasion to exert his *understanding* or to exercise his *inventions* in finding out expedients for removing difficulties which never occur” (Rosenberg, 1965: 127, emphasis in original). Frugality, it appears, can revive the role of such human capabilities and cognition in the discourse on innovation in a significant way.

If frugal innovation is much more understood in the above terms, it can give a new impetus to innovation studies. Up to now, definitions of what innovation is and entails have been mostly defined and informed by the experiences of industrialized countries, which more often than not has led to generalizations emphasizing the non-existence of innovation in low-income societies. The annually published Global Innovation Index, which ranks the innovation ecosystem performance of about 130 countries each year, is a good example of this. If innovation ecosystems and how these work in industrialized countries are taken as a point of reference, it is no surprise to find the majority of low-income countries at the bottom of the ranking.⁷ Frugal

innovation scholarship seems to have the potential to offer an alternative, different and critical perspective on this, provided it goes beyond the ‘definitional war’ and starts to consider and unravel further the heuristics of frugal innovation and frugality, and the processes and practices behind it. The question then does not become anymore whether a product, service, system or process is a frugal innovation or not, but different innovations may have different degrees of frugality. An innovation can be more or less frugal, depending on the extent to which it adheres to various criteria that characterize frugal(ity). Hindocha et al. (2021, p. 654) seem to hint at such an approach by suggesting that “defining frugal innovation as a concept should not deter from focusing on its core aim and identifying an FI [frugal innovation] may be best achieved by comparing it to an incumbent alternative, rather than against an ill-defined concept”. A systematic methodology and clear criteria to measure frugality in innovations still need to be developed, which makes it at present still difficult to clearly distinguish between more frugal and less frugal innovations.

Discussions within the literature make it sufficiently clear that the exact boundaries of what frugal innovation is and entails are not yet fully clear. This may problematize the development of an adequate conceptual and analytical framework, but we also observe that the current frugal innovation discourse is multidimensional, refers to and tries to bring on board several concepts, notions, theories and methodologies with the objective to capture and understand better an emerging phenomenon in today’s innovation practices across the globe and to feed our thinking on what innovation actually is, entails and should be aiming for. This has not been done in a very systematic way yet, as most authors of the reviews on frugal innovation also conclude. However, some key embryonic elements in the current frugal innovation discourse exist that – in our perception – with a thorough theoretical and empirical investigation, can lead to the development of an innovative and rigorous analytical framework that will be able to capture the phenomena under study and make frugal innovation a distinctive academic field of study within innovation studies.

We observe the following distinctive features in the frugal innovation scholarship that makes it different from other discourses on innovation:

1. As explained above, the frugal innovation and frugality discourse broaden the idea of what innovation is and entails by drawing the attention to innovation in or for low-income (absolute or socially constructed) resource-constrained settings, something that for long has been ‘below the radar’. By having this attention and focus, the frugal innovation scholarship can (re)introduce and feed critical thinking on the implicit (western-based) assumption that innovations always originate in industrialized countries and could lead more generally to a different, maybe more human-centered, innovation practice, which is more inclusive and more relevant to more people (see Jain and Bhaduri, 2021).
2. Therewith it can also contribute to a more critical analysis of today’s interdependencies, power relations and inequalities in today’s global innovation configurations and creates a better entry to the discussion on the relationship between technology, innovation and (social, economic, environmental) sustainability.
3. By having and applying this broader understanding of what innovation is and entails, the frugal innovation discourse focuses more than most other “standard” innovation on both low-end and high-end (4IR) technologies as enablers for frugal innovation.
4. The frugal innovation discourse draws attention to the role of multiple actors involved in the innovations process and how they interact (‘co-creation’ in innovation, ‘polycentric

innovation’), going beyond the actors and interactions conventionally explained in an innovation system framework, such as non-firm entities, or informal sector entrepreneurs and organization actors that include non-firm entities. Including these actors in analyses of innovation systems could also provide entry to the development of a critical perspective as mentioned under point 2.

As editors of this *Handbook*, we aim for the Frugal Innovation discourse to further develop into a longer-term viable concept and approach that substantially contributes to the academic and societal debate on new or alternative innovation models that take a more global, multi-actor, and sustainability perspective. The *Handbook* is meant to reflect this search to broaden and deepen the academic discourse, offering a more comprehensive scope as compared with many other similar publications. This *Handbook* contains contributions on how to include frugal innovation thinking in a range of disciplines and how to embed frugal innovation in transdisciplinary thematic debates. Moreover, the handbook explores the role of technology as an enabler of frugal innovation, and it investigates a wide variety of actors with distinct motivations who are involved in developing and implementing frugal innovations. The structure of the handbook is further explained in the next and final section of this chapter.

1.5. HANDBOOK STRUCTURE

This section outlines the structure of the *Handbook*. Apart from briefly introducing the various chapters, we characterize the four parts in which the contributions are organized to enable potential readers to quickly identify those chapters that may particularly interest them. The first set of chapters aims to include further conceptualizations of frugal innovation and frugality in particular disciplines and theories: economics, decision-making theory, development studies and history. In Part 2, we bring together a set of chapters that aim to embed frugal innovation and frugality into broader transdisciplinary thematic debates on: sustainability, circular economy, gender, governance, legitimacy, and justice. Part 3 focuses on the role of technology as an enabler, how designing and engineering processes can be made more frugal, and how frugal innovations are also (becoming) part of the digital revolution and in science labs. The final set of chapters focuses on how specific lead actors, not only large and small businesses but also universities and public entities, aim to develop and implement frugal innovations and new business models in various coalitions with other formal and informal actors.

1.5.1. Part 1. Including Frugal Innovation Thinking in Disciplinary Debates

Part 1 consists of four chapters that include frugal innovation in the following disciplinary debates: history (Versluijs and Sluiter), economic theory (van Beers and Leliveld), political economy and critical development studies (Pansera), and behavioral decision theory (Bhaduri et al.).

Part 1 starts with a chapter by Versluijs and Sluiter, who argue that innovation has historically been about redesigning and finding ‘good enough’ solutions, making what we now call frugal innovation the norm throughout most of history, except in recent centuries of Western-dominated technological development. They add the concept of anchoring to emphasize that innovations are more likely to become successful when they can be effectively

integrated and accommodated in an existing context. Therefore, they talk about a return to frugal innovation instead of seeing it as something new.

Van Beers and Leliveld's chapter explores how theoretical observations from innovation economics and a social entrepreneurial perspective could provide stepping stones towards a better understanding of frugal innovation. Two takeaways on furthering theoretical attempts to understand frugal innovations are presented. The first is working out Comprehensive Schumpeterian models where dynamic patterns of polycentric innovation networks can be examined thoroughly. The second is working further on the role of (networks of) social entrepreneurs as frugal innovators and providing them with a broader validity.

The chapter by Pansera provides a political economy and critical development studies perspective, showing how to move beyond the imaginary tales of the single male heroic inventor, beyond the obsession with a technological fix to societal challenges, and to move beyond a depoliticized way of framing technology and scarcity. The chapter argues that a broader and political understanding of poverty and social exclusion is needed to investigate when frugal innovations are more likely to enable transformations that go beyond a market logic and standard economic analysis.

The chapter by Bhaduri et al. starts from behavioral decision theory and looks at how frugality considerations influence decision-making by innovation actors in the informal sector. They show how intuition, judgment and learning from 'what actually works' are key to understanding how people innovate in the informal economy. Therefore, while much of the literature on frugal innovation focuses on how to deal with scarcity in physical and material resources, this behavioral approach helps to understand how intangible factors, such as individual idiosyncrasies and experiential knowledge, steer locally embedded frugal innovation processes.

1.5.2. Part 2. Embedding Frugal Innovation in Transdisciplinary Thematic Debates

The chapters in Part 2 embed frugal innovation in broader thematic debates on: sustainability (Knizkov and Arlinghaus), circular economy (Levänen et al.), gender (Vossenbergh and Hai), governance for sustainable development (Parthasarathy and Aoyama), legitimacy (Schouten and Knorringa), and on justice (Hazenberg and Bhaduri). The first chapter in Part 2 focuses on the link between sustainability and frugal innovation. Knizkov and Arlinghaus challenge the often-implicit assumption that frugal innovations inherently generate positive sustainability impacts, and they lay the foundation for more nuanced empirical future research on the complex causalities between frugal innovation and sustainability. The chapter by Levänen et al. combines parts of the works of literature on frugal innovation and circular economy. It argues that both narratives revolve around resource scarcities and that frugal innovators can act as creative change agents in circular economy transitions, especially in low-income settings.

In their chapter on gender and frugal innovation, Vossenbergh and Hai observe an absence of a gender lens in frugal innovation studies. The adoption of such a lens, they argue, can lead to more inclusive concepts and discourses on frugal innovation, acknowledging both men's and women's practical and strategic needs and long-term interests. It would also allow for a better identification of which frugal innovations can actually rattle the cage of marginalization and exclusion and act as powerful means toward empowerment and equality. The authors advocate an application of feminist theories in frugal innovation studies and invite frugal innovation scholars to engage in a reflexive dialogue on how gender hierarchies and beliefs are embedded in their discourses.

The chapter by Schouten and Knorringa shows why legitimacy is important but, so far, rather ignored in the emerging discourse on frugal innovation. It explains how three main types of frugal innovators (profit-oriented private firms, NGOs, grassroot innovators) employ different legitimization strategies, and they explore three more generic legitimization challenges for frugal innovations, which need to be addressed more systematically in future research. The final chapter in Part 2, by Hazenberg and Bhaduri, develops the first steps towards a justice and fairness approach for frugal innovation, with a focus on fairer institutional structures that can promote the generation and distribution of frugal innovations that prioritize the needs of the (most) disadvantaged. With examples from the Covid pandemic, this chapter also reinforces and substantiates the more general observation in this *Handbook* that the frugal innovation discourse is moving from being seen as a stop-gap solution for the poor(est) to a more systemic phenomenon across the globe, perhaps, especially in situations where quick and ‘good enough’ solutions are paramount.

1.5.3. Part 3. Technology as an Enabler

Part 3 focuses on the role of technology as an enabler, keeping in mind that the development and the implementation of (new) technologies also lead to new challenges in terms of addressing possible new inequalities and barriers to inclusion. The first two chapters of Part 3 investigate design processes (Doorn; Diehl et al.) The following two chapters focus on frugal engineering processes (Ceron-Chafra and Lindeboom, Wimschneider and Agarwal), while Rao’s chapter focuses on design and engineering to develop so-called ‘advanced frugal innovations’. The chapter by Sekhsaria explores frugality in a high-tech science lab, and the final two chapters connect frugal innovation to the Fourth Industrial Revolution (Ritchie; Van Tuijl and Knorringa).

The first chapter in Part 3, by Doorn, offers a conceptual contribution on the potential usefulness of value-sensitive design thinking for frugal innovation. To apply the growing literature on ethics of technology to frugal innovation thinking, it suggests thinking in terms of ‘design for context X’ rather than ‘design for value Y’, to avoid a too narrow focus on one particular value and to enable a broader focus on the variety of elements that need to be taken into account when designing in and/or for a resource-constrained context. The chapter by Diehl et al. explores how frugal design processes can increase access to medical devices such as diagnostic equipment. The authors present a case study of a frugal design for a centrifuge for sample preparation for Schistosomiasis. The final design of the frugal centrifuge is proven to be a fully functioning centrifuge according to medical standards. It can be produced locally by 3D-printed and off-the-shelf components and operated by limitedly trained healthcare workers. However, 3D-printing facilities are still rather scarce, and other options also need to be considered.

The subsequent two chapters start from an engineering perspective. First, Ceron-Chafra and Lindeboom investigate how water and sanitation systems differ across the globe, and they specifically contrast the centralized, linear and resource-affluent systems built in rich countries with the more decentralized circular and resource-constrained systems in the Global South. Frugal innovation is then brought in as a concept to effectively bring together the various strands in a strategy to develop more systematic engineering solutions to global water and sanitation challenges. Second, Wimschneider and Agarwal analyze the new product development (NPD) process to explore how frugal engineering capabilities can be developed according

to various iterative steps. The chapter presents a case study of a frugal diagnostic device called ‘iBreastExam’, which offers a cost-effective, mobile and radiation-free breast-cancer examination. In turn, the chapter by Rao brings in the idea of ‘advanced frugal innovations’ for design and engineering solutions that combine sophisticated technology with inherent frugality, aiming at no-frills products while using high-tech inputs. The chapter stresses the need to involve proper scientific principles in designing and engineering frugal innovations. Such scientific formalization can encourage a wider group of Science and Technology designers and developers to adopt more frugal ways of designing and engineering. The next chapter, by Sekhsaria, also explores the role of frugal innovation and Jugaad in a high-tech environment and shows how in his case study – a modern scientific laboratory in India – one cannot ignore the role of Jugaad in this context. The final two chapters of Part 3 focus on how frugal innovations also become part of the digital revolution. Ritchie identifies specific ICTs, with a focus on mobile phone apps, as frugal innovations that enable refugees to become more self-reliant and resilient in fragile contexts. The final chapter, by van Tuijl and Knorringa, looks at the ways in which frugal innovations and frugal spare parts are offered through digital transaction platforms and how aid agencies and MNEs mobilize frugal innovators through innovation platforms.

1.5.4. Part 4. Actors, Business Models and Blurring Boundaries

Part 4 brings together a set of chapters with case studies on how various types of lead actors develop and implement frugal innovations. The first three chapters deal with for-profit companies as lead actors (Tiwari and Herstatt, Trompette and Cholez, and Voeten). The chapter by Howell focuses on social enterprises, while the chapter by Onsongo investigates the role of public sector engagement with frugal innovation. The final two chapters focus on the role of universities as lead actors in developing and implementing frugal innovations (Fischer et al., and Dijksterhuis et al.).

The first chapter of Part 4, by Tiwari and Herstatt, investigates the innovation strategies of multinational enterprises and how they cope with the shift of lead markets towards emerging economies. They show how multinational enterprises can benefit from a simultaneous presence in both rich and emerging markets, offering ‘affordable excellence’, a key condition for longer-term success in mainstreaming frugal innovations. Another layer of complexity is added by Trompette and Cholez, who analyze both the initiatives by multinational companies and start-ups in capturing the market standalone energy solutions such as solar lamps for off-grid populations in Africa, as well as their emerging competitors that import generic unbranded Chinese imitations through locally embedded African-Chinese trading networks. They argue that value chains already embedded in local and informal economies are better able to serve the needs of the poorest and that in the higher-end market segments, new business models emerge that can mainstream the use of frugal innovations. The next chapter, by Voeten, analyzes a frugal innovation process in a ceramics cluster of small producers in Vietnam. A small group of intrinsically motivated producers took the initiative to introduce a frugal and yet more-advanced kiln technology, leading to less pollution, increased productivity and alleviated local poverty. Based on this case, in which formal knowledge institutions and government agencies only got involved in later stages of the innovation process, Voeten develops propositions for future research on how to integrate frugality in innovation processes.

The final four chapters focus on non-commercial lead actors. The chapter by Howell analyzes two social enterprises that sell bottled drinking water in Kenya and Rwanda to explore how social enterprises can balance value creation (reaching low-income consumers and achieving developmental impacts) and value capture (making sufficient margins to sustain and possibly grow the social enterprise). Howell finds that (1) these social enterprises find it very difficult to reach the poorest consumers, (2) offering bottled drinking water is essentially a stop-gap solution to infrastructural deficiencies, and (3) future research would need to focus more on developing systems-level frugal solutions. The chapter by Onsongo takes the next step in exploring how frugal innovation principles apply in public service delivery such as healthcare and energy provision in Kenya. The cases reveal that frugal innovation in public services calls for collaboration with other actors, a change in mindset, community engagement, and experimentation and that it increasingly relies on digitization and frugal business models. The final two chapters investigate the role of universities as lead actors. The chapter by Fischer *et al.* focuses on the collaboration of universities with businesses and explores how universities can give meaning to their mission of creating positive societal impact, with a case study of the University of Campinas in Brazil. The positive societal impact of such university–business cooperation is achieved through technology transfer from applied university-based research, preparing and supporting students to create frugal innovation start-ups and to become skilled employees in firms developing and implementing frugal innovations. The chapter by Dijksterhuis *et al.* investigates the role of universities in relationships with both businesses as well as with communities. It explores two types of university-driven frugal innovations. One is with businesses and focuses on making breakthrough technologies and radical inventions more frugal. The second type aligns more with the university’s education and community engagement responsibilities and is carried out through co-creation with local communities. By combining both types of frugal innovation, universities are argued to possibly offer a bridge between so far rather divergent streams in the frugal innovation literature.

NOTES

1. Many more examples can be given. We earlier indicated that the emerging scholarship on frugal innovation mainly focuses on frugal innovation examples developed in high income, formal settings. For more examples of frugal innovations that have been developed in low-income, informal settings we refer the interested reader to websites such as <https://nif.org.in/> or <https://www.facebook.com/POC21/> (last accessed, May 30, 2022).
2. See Agarwal and Brem (2017, 2021), Albert (2019), Bhatti *et al.* (2018), Brem and Wolfram (2014), Dabić *et al.* (2022), D’Angelo and Magnusson (2021), Dima *et al.* (2022), Hindocha *et al.* (2021), Hossain (2018, 2020), Jain and Bhaduri (2021), Knorringa and Leliveld (eds.) (2018), Levänen *et al.* 2017, McMurray and De Waal (2019), Melnikova and Gilsanz (2022), Pisoni *et al.* (2018), Ratten (2019), Rosca *et al.* (2018), Tatum and Russo (2020), Tiwari and Kalogerakis (2016), Tiwari *et al.* (2016), Weyrauch and Herstatt (2016), Zeschky *et al.* (2011, 2014).
3. The term ‘frugal engineering’ was introduced in 2006, but Renault had embarked on a ‘frugal’ route much earlier. On a visit to Russia in 1997, Renault’s then chief executive, Louis Schweitzer, was discomfited to discover that the locally made, \$6,000 Lada was outselling his company’s more showy, expensive cars by a considerable margin. Five years later, Renault unveiled its \$6,000 no-frills Dacia Logan (Radjou *et al.*, 2012a).
4. In other parts of the world *Jugaad* is known, for example, as *zizhu chuangxin* (China), *gambiarra* (Brazil), D-I-Y (‘do it yourself’) (USA and parts of Europe), *jua kali* (East Africa) or *système d*

- (France). Also, these words to mostly refer to a quick fix, and easy way to deal with unforeseen circumstances and resource constraints.
5. However, so far there seem to be limited examples of reverse innovation (Simula et al., 2015). Examples include GE's earlier-mentioned portable electrocardiograph machine which was originally developed for doctors in India and China, and later also sold in the USA at significantly lower prices than similar products. Tata aimed to launch the Tata Europe – based on the 'frugal' Tata Nano – in the European market, but it never reached the expected market (nor did the Nano in India). Nestlé started to sell low-cost, low-fat dried noodles originally meant to serve the population of rural India as a healthy alternative in Australia and New Zealand.
 6. Resource constraints here meaning the resources at the disposal of a single individual or an informal group vis-à-vis large firms
 7. Lack of data on innovation ecosystems – either formal or informal – in low-income countries may distort the picture here; when not all parameters can be measured, the ranking might accordingly be lower.

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