



Regional studies and frugal innovation: a missing link?

Fayaz Ahmad Sheikh, Rhiannon Pugh, Xiaobo Wu & Soumodip Sarkar

To cite this article: Fayaz Ahmad Sheikh, Rhiannon Pugh, Xiaobo Wu & Soumodip Sarkar (2023): Regional studies and frugal innovation: a missing link?, *Regional Studies*, DOI: 10.1080/00343404.2023.2222136

To link to this article: <https://doi.org/10.1080/00343404.2023.2222136>



© 2023 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



Published online: 11 Jul 2023.



Submit your article to this journal [↗](#)



View related articles [↗](#)



View Crossmark data [↗](#)

Regional studies and frugal innovation: a missing link?

Fayaz Ahmad Sheikh^a, Rhiannon Pugh^b, Xiaobo Wu^c and Soumodip Sarkar^d

ABSTRACT

Innovation has been a key topic of interest for the regional studies community. In particular, the regional characteristics and impacts of innovation have been a popular theme of enquiry and theorisation, and the community has been at the forefront of discussions around regional innovation systems, in particular. However, we see a large gap in the current state of the art around frugal innovation. The focus of this paper is to place this topic at the heart of our discussions of regional innovation. This is done by providing a case study of frugal innovations in Kashmir over the period of the COVID-19 pandemic, illustrating the urgency and relevance of exploring frugal innovation at the regional level, especially as a rapid place-based crisis response, specifically in a developing nation.

KEYWORD

frugal innovation; regional innovation system; COVID-19

JEL O3

HISTORY Received 12 May 2021; in revised form 31 May 2023

1. INTRODUCTION

There has been a recent wave of interest in resource-constrained innovation practices from emerging economies, particularly on their reliance on frugal innovation of 'doing more with less for more' (Prabhu, 2017, p. 1). This perspective explicitly acknowledges resource scarcity as influencing the innovation process. Research interest in frugal innovation has been dramatically rising in the last decade (Sarkar & Mateus, 2022). Surprisingly, one area that we still know little about is the practice of frugal innovation as a regional innovation strategy. This paper argues for a centring of frugal innovation within our discussions in regional studies and economic geography perspectives, connecting in particular to the regional innovation systems (RIS) approach. We illustrate how frugal innovation can be studied and make the argument for its importance as a field of enquiry in regional studies by presenting recent research into frugal innovations as a response to the COVID-19 pandemic in the Indian region of Kashmir. We draw upon 13 cases of bottom-up entrepreneurial enactment of frugal innovation to respond to the acute shortage of personal protective equipment (PPE) in Kashmir.

Our main motivation in writing this paper is twofold. First, we think it is of utmost importance that the regional

studies community has a greater engagement with the concept of frugal innovation, particularly because it is the predominant mode of innovation and central activity within socio-economic functioning in huge swathes of regions across the world. Looking at the flagship journal *Regional Studies*: if we search for 'frugal innovation' in the title we get zero results, and only five that use the phrase anywhere in the paper. For comparison, searching 'regional innovation' gives 2437 results. Second, we find that frugal innovation has been a vital and rapid response mechanism to the COVID-19 pandemic, and that the experiences of frugal innovators in Kashmir provide some insightful examples of how frugal and peripheral innovation actors (Park et al., 2021) can be harnessed as a crisis response in needy communities.

In addition to making an intervention on a conceptual or theoretical level, calling for more engagement with frugal innovation on behalf of scholars of regional innovation and development, we illustrate how and why we should study frugal innovation processes with a contemporary example. Regions require tools that aid their search for new markets, innovation opportunities and upgrading patterns to recover from the 'shock' of COVID-19 (Bailey et al., 2021). COVID-19, Bailey et al. (2021, p. 1963) argue, 'has taught us that the greater the change, the greater the disruption, but also the greater the disruption,

CONTACT Rhiannon Pugh  Rhiannon.pugh@circle.lu.se

^aZhejiang University International Business School (ZIBS), Zhejiang University, Hangzhou, Zhejiang, China

^bCentre for Innovation Research (CIRCLE), Lund University, Lund, Sweden

^cSchool of Management, Zhejiang University, Hangzhou, Zhejiang, China

^dDepartment of Management, University of Evora, Évora, Portugal

the greater the chance of change'. The practice of frugal innovation as a rapid response to COVID-19 (Corsini et al., 2021; Harris et al., 2020; Park et al., 2021; Sarkar, 2021; Vesci et al., 2021) gives us the opportunity to examine this phenomenon as a regional response strategy.

2. LITERATURE REVIEW

2.1. What is frugal innovation and why is it important?

Scholars from the regional studies community have increasingly challenged the idea of innovation as a primarily urban affair, illustrating how innovation happens in peripheral regions in different ways to what we see in the core (e.g., Grillitsch & Nilsson, 2017; Martinus et al., 2020; Melançon & Doloreux, 2013). Different typologies of RIS have emerged according to different regional profiles and institutional settings (Asheim & Coenen, 2005). Innovation is viewed as complex, unequal over space, time and social groups, and we increasingly recognise the potential negative effects for certain regions and groups of people of an uneven mode of innovation and development (Clark, 2020). Indeed, in addition to a regionally differentiated view on innovation, an evolutionary approach is called for that appreciates the change in innovation systems over time as well as place (Iammarino, 2005).

There have also been challenges to the idea that innovation is primarily a high-tech, or radical, affair, with contributions around inclusive, sustainable and social innovation helping to nuance our understanding of the concept (Kaplinsky, 2018; Nicholls et al., 2015; Onsongo, 2019). These alternative perspectives have been especially important in empirical cases stemming from developing economies, where the predominant mode of doing innovation may be shaped differently, and where additional challenges may exist around system failures (Altenburg, 2011; Lundvall et al., 2011; Rodríguez et al., 2014).

Against the wider backdrop of these critical innovation perspectives, we introduce the concept of frugal innovation as a regional innovation response under

resource scarcity. Frugal innovation has been analysed under many different empirical settings, leading to a wide range of contributions and overlapping concepts. Examples of overlapping terms include 'reverse innovation' (Govindarajan & Trimble, 2012), 'Gandhian innovation' (Pralhad & Mashelkar, 2010), 'empathetic innovation' (Gupta, 2016), 'inclusive innovation' (George et al., 2012) and 'grassroots innovation' (Gupta, 2016; Sarkar & Pansera, 2017). Local vocabulary has also been adopted to describe these innovations, such as social technologies in Brazil and *jugaad* in India (Agarwal et al., 2016; Smith et al., 2016).

Despite this fragmented picture, some fundamental principles emerge from this wide perspective. In their recent systematic review of frugal innovation, Sarkar and Mateus (2022) identify common themes around the contexts, motivations, actors, processes and outcomes of frugal innovation in an integrated framework. Frugal innovation involves cost reductions from the producer point of view and affordability for the consumer, operating at an optimal level of performance by focusing on core functionalities, reliability, simplicity and robustness. To produce frugal innovation, there is a level of flexibility for adaptation to different environments and resources. These ideas were succinctly summarised by Agarwal et al. (2021): qualifying conditions for any innovation to be termed frugal to revolve around three aspects: significant cost reduction, optimal performance and a focus on essential functionality. Table 1 illustrates the key characteristics and examples of different innovation types, which helps to shed light on some of the differences between frugal innovation and other innovation types.

Frugal innovation does not simply imply low-cost and quality adaptations of Western products (Sarkar & Mateus, 2022; Zeschky et al., 2011), but aims at optimising the cost-performance relationship (Zeschky et al., 2011). Looking at the Indian context of our study, Agnihotri (2015) sees frugal innovation as one of the four dominant modes of low-cost innovation that take place in emerging markets, along with *jugaad*, value and reverse innovation.

Table 1. Examples of different innovation types and their characteristics.

Innovation type	Key characteristics	Examples
Frugal innovation	<ul style="list-style-type: none"> • Focuses on significant cost reductions, optimal performance and essential functionality • Often involves community-led initiatives that focus on social value and affordability 	<ul style="list-style-type: none"> • Tata Nanocare, M-Pesa mobile money transfer, portable ultrasound machine • Biomass -fuelled energy generator, cotton stripper, clay fridge (Mitticool)
Incremental innovation	<ul style="list-style-type: none"> • Improves already existing products or processes through small changes 	<ul style="list-style-type: none"> • iPhone updates, minor improvements on the manufacturing processes
Disruptive innovation	<ul style="list-style-type: none"> • Creates new products or services that disrupt existing markets, often targeting underserved or overlooked customer segments 	<ul style="list-style-type: none"> • Digital platforms such as Airbnb and Uber
Radical innovation	<ul style="list-style-type: none"> • Involves the development of entirely new technologies, products or business models that transform markets and create new industries 	<ul style="list-style-type: none"> • Personal computers, electric cars, blockchain technology

While frugal innovation perspectives have provided a vital lens for exploring innovation in low-cost and bottom-up contexts, there are some limitations to the field as it stands. Discussion of knowledge exchange processes are lacking, even though this is a core focus of more traditional innovation research. The role of government and policy in supporting and driving the emergence and spread of frugal innovations has been overlooked: such approaches may hold great promise in delivering low-cost solutions to problems, thus improving social welfare (Sarkar, 2021). Sarkar (2021) also highlights the need to understand how this can happen collaboratively with businesses and communities, in the spirit of the quadruple helix. Although there is increasing interest in the more-than-economic roles of universities in driving social innovation, including in Global South contexts (Thomas & Pugh, 2020), very little is known about how universities fit into the frugal innovation picture. However, the most telling gap in our knowledge is frugal innovation in the context of regional innovation, which we discuss next.

2.2. The confluence of frugal and regional innovation

The absence of a discussion involving regional innovation in the current frugal innovation literature is surprising, given that the regional (or geographical) perspective on innovation from an institutional perspective is often latent. Frugal innovation allows us to see how innovation development can best be achieved within specific social contexts, in particular constrained environments with institutional voids (Bhatti et al., 2018; Harris et al., 2020; Prahalad & Mashelkar, 2010; Radjou & Prabhu, 2015; Sarkar, 2021). The concept has been advocated especially by scholars observing innovation processes in the Global South (Godin et al., 2021; Muchie et al., 2017). However, the potential of frugal innovation perspectives for less favoured regions in the Global North, and for resource-constrained actors, such as community organisations, social innovators, small businesses, governments with shrinking budgets, etc., has been thus far underexplored.

A defining characteristic of frugal innovation is its local specificity, which makes it a prime candidate for analysing at a regional level. This locality was emphasised by Hoffecker (2018, p. 4) in his consideration of the frugal innovation process as ‘developing and introducing into use new and improved ways of doing things compared to existing practice within a specific local context, which involve local people and resources in addressing challenges and opportunities present within that context’. Frugal innovation revolves around finding rapid and durable solutions for specific local problems, and many examples discuss the sustainability of the local system of production, distribution and consumption (Seyfang & Haxeltine, 2012; Seyfang & Smith, 2007; Smith et al., 2016). Studies have documented frugal innovation’s multiple pro-social motivations in solving local problems along with these innovations’ roles in fostering community relations, individual self-esteem, alternative discourses, and economic value through greater competitiveness and entrepreneurship

(Gupta, 2016; Seyfang & Smith, 2007; Sheikh, 2019; Smith et al., 2016).

Despite the relevance of the local and regional context in frugal innovation development, in their meta-synthesis of 36 studies comprising 95 cases, Sarkar and Mateus (2022) do not find a single mention of frugal innovation in the regional innovation space. This is despite the fundamental logic for considering the regional context within frugal innovation being quite obvious. Frugal innovations’ emergence has to do with proximity to the problem (Corcini et al., 2021) and the context of final users determines success or failure (Sarkar & Mateus, 2022). Understanding the local and regional context in which frugal innovation is being developed is vital as low-cost products from other developed contexts would probably not be useful or appropriate (Kuo, 2017). The embedded regional entrepreneurs possess this knowledge of the user environment, either themselves or through close relatives and local community (Pansera & Sarkar, 2016). Even for multinational companies, whether or not home based, it is essential to focus on the regional environment, needs and desires of the local and regional target market (Sarkar & Mateus, 2022).

These insights lead us to posit that frugal innovation has an inherent regional orientation: being born out of contextual needs, resources, opportunities and cultures. It is well established, for example, through work on RIS around the world (Asheim et al., 2019; Lundvall, 2011; Padilla-Perez et al., 2009/2011), that innovation processes and outcomes have a strongly regional profile, and adding frugal innovation into this analysis merely extends this logic. In line with this work, we depart from this classic RIS framing due to the need to appreciate that the processes, and dividends of innovation are thought to orient to a subnational scale. Innovation is thus understood as socially and territorially embedded, which cannot be divorced from its institutional and cultural context (Asheim, 2012).

The key argument underpinning the RIS approach is that learning has a specifically regional context; knowledge is hard to exchange over long distances being heavily imbued with meaning arising from the social and institutional context in which it is produced, and regions have individual knowledge capabilities and resources (Asheim & Gertler, 2005; Cooke, 1998). Taking this standard RIS conceptualisation, we add to it the case of frugal innovation. However, we posit that the social and territorial embeddedness of innovation and knowledge exchange, and the importance of the specific institutional context in understanding this, will be as relevant to a study of frugal innovation as any mainstream innovation study. We test this theory with our case study of frugal innovations during the COVID-19 pandemic in Indian Kashmir.

3. CASE INTRODUCTION AND METHODS OF ENQUIRY

3.1. Historical context: the COVID-19 pandemic

A flourishing of frugal innovation practices has been noticed in locations around the world, in response to the

profound public health crisis heralded by the spread of COVID-19. Existing resources have been reused, re-deployed and repurposed (Harris et al., 2020). Bottom-up entrepreneurship, home-grown efforts and crowdsourcing innovations have sparked creative collaborations to address pertinent problems (Ramadi & Nguyen, 2021). Noteworthy cases include refitting trains in India and Pakistan into hospital wards for COVID-19 patients; using hydroxychloroquine, a prophylactic malaria treatment, to relieve COVID-19 symptoms; and reusing available materials to create do-it-yourself masks and ventilators (Harris et al., 2020). Haidare (2020) finds car parts being repurposed to make ventilators in Afghanistan; and we find social media efforts, such as the ‘Open Source C19Medical Supplies’ group on Facebook, helping to rectify global medical equipment shortages (Petri, 2020; Sarkar et al., 2022). Vesci et al. (2021) uncover digital makers using digital technologies for customised products playing a significant role in fighting the pandemic and offering fast solutions to critical problems.

This insight that pandemics can induce innovations is not new: it has already been studied how previous pandemics led to important scientific and public health innovations (e.g., Barr et al., 2020; Hays, 2005). The novel element of our study is the focus on frugal innovation as a key response during the COVID-19 crisis at the regional level. As most frugal innovations are created either by reusing or repurposing locally available materials or are rapidly deployed without following a formal set of procedures, this framework is especially useful for the current setting. That is not to say we hold up such frugal innovations as ‘ideal cases’ medically or scientifically; we are

approaching them as a response to regional public health crises where due to various factors, affecting regions in both the Global North and South, healthcare systems became overwhelmed, and people turned to their own resources and creative thinking to problem solve under a high-pressure scenario.

3.2. Regional context: Jammu and Kashmir

Jammu and Kashmir, the northernmost part of India, is administered as a union territory with a population of 1.23 crores according to the 2011 Census (estimated at almost 15 million today). The economy of Jammu and Kashmir largely revolves around services and agriculture. This region has a contested history, and the geopolitical situation is complex. This ‘region’ is complex and contested, but for simplicity we use the administrative delineation of the Indian government. Jammu and Kashmir is a landlocked state surrounded predominantly by (1) the Lesser Himalayas, or ‘Jhelum Valley’ (Kashmir); (2) the Inner Himalayas or the ‘Indus Valley’ (Ladakh and frontier areas) also called ‘Trans Himalayas’; and (3) the Outer Himalayas, also called ‘Southern Mountain range’ (Jammu).

The government spokesman for the territory, Rohit Kansal, confirmed the first case of COVID-19 on 18 March 2020. This research was conducted during the first and second waves of the pandemic, which occurred during spring of 2020–21. It is worth bearing in mind that during the second wave in 2021, the situation in India worsened significantly beyond the first-wave scenario. It soon became clear that public and private hospitals might be lacking in supplies; for almost 15 million people, Jammu and Kashmir had 180 ventilators in March 2020, almost all of which were already in use – leaving nearly none for new COVID-19 cases, and PPE shortages (e.g., N95 masks and coated gowns) affected the region.

Concerned by the pandemic’s acceleration and accompanying disruptions in the global supply chain, many local innovators attempted to invent low-cost bottom-up innovations to mitigate the COVID-19 crisis. They contributed their designs and prototypes to hospitals and universities in Kashmir for quick use. Many innovators also shared their designs on open-source platforms to help people in other parts of the world. Through these various dissemination and networking mechanisms, it was possible to identify particular cases of frugal innovation to follow up with qualitative research. Table 2 summarises the information about those cases, representing a range of different rapid frugal innovation responses.

3.3. Methods of enquiry

To examine the nuances and underpinnings of informal sector innovations, qualitative approaches such as grounded theory, interpretative case studies, organisational ethnography, among others, are often applied over quantitative methods (Pansera & Sarkar, 2016). Moreover, to establish a generalisability of inferences, and permitting richer and more nuanced interpretations

Table 2. Frugal innovation cases.

Number	Innovation type	Number of innovators	Pseudonym
1	Ventilator	3	Rafiq, Javaid and Gowhar
2	Robotics	1	Zamin
3	Disinfection and sanitisation	2	Ibrahim and Zahor
4	Disinfection and sanitisation	1	Jamsheed
5	Splash guard	1	Azad
6	Face masks	1	Faizan
7	Face masks	1	Farooq
8	Digital apps for contact tracing and online consultation	1	Tariq
9	Overcoming social stigma	2	Saju and Elisa
10	Ventilator	1	Wasu
11	Ventilator	1	Zabi
12	Ventilator	2	Ali and Daniel

of a phenomenon (Eisenhardt & Graebner, 2007), qualitative approaches such as case studies are preferred.

To capture the nuances of frugal innovations, we employed an inductive method by examining multiple case studies. Inductive lines of enquiry are especially recommended when research deals with ‘how’ types of question, and where the context and experiences of the protagonists, are critical. In particular, we adopted a grounded theory approach in which theoretical insights emerge from interpretation of qualitative data such as semi-structured interviews, documents and direct observations (Gioia et al., 2013).

Considering the complexities of the informal sector and the innovations that emerge from this sector of economics, the research design adopted here is a qualitative multiple-case study based on observational data, semi-structured interviews and secondary data from newspaper and media accounts, of frugal innovators.

3.4. Case selection and data

This work is based on data gathered from different parts of Jammu and Kashmir from various frugal innovators. We adopted maximum variation sampling, purposefully picking select cases to obtain variation on the dimensions of interest employed (Eisenhardt & Graebner, 2007; Yin, 1994). This sampling technique allowed us to get a divergent perspective on frugal innovation.

For the case selection, we analysed newspapers and social media websites to identify 35 key innovators in April 2020, responding to COVID-19. Then coupling the principle of maximum variation with logistical challenges posed by the lockdowns from undertaking many direct interviews, we purposefully shortlisted 17 innovators who in groups and individually worked on 12 innovations (Table 2). All the innovators were male, except case 9 (overcoming social stigma).

To corroborate with our research objectives, we used the following data sources: interviews (primary), media coverage (secondary) and *in situ* personal observation of innovations (Table 3). This deployment of multiple sources of evidence helped in triangulating the data and improved the accuracy of the thematic analysis. The

interviews were conducted in Kashmir from May 2020 to March 2021, using a mix of English, Urdu and Kashmiri, with all notes taken in English. Online meetings using various platforms were also conducted. These interviews usually lasted between one and two hours, and were open-ended. Three different rounds of data collections were carried out throughout the year in May–June, September–October (2020) and February–March (2021). Three rounds were conducted to ascertain the year-long progress of innovation and the impact they would create. Table 3 summarises our data collection approach.

3.5. Analysis of data

An iterative procedure of shifting between theory and data was used for data analysis (Eisenhardt, 1989). The major goal was to figure out how resource-constrained bottom-up innovators were able to create their ideas without any outside assistance. We used an inductive, in-depth, field-based method for elaborating on existing and previous theories (Eisenhardt, 1989). We deliberated collaboratively, going back and forth between the data and the frugal innovation literature. All documents were cross-checked to ensure that all relevant aspects were captured in the themes discussed below.

4. ANALYSIS: FRUGAL INNOVATION AS RAPID (REGIONAL) CRISIS RESPONSE

We find some particularly pertinent themes about our cases that can explain the notable emergence of frugal innovations during the pandemic, and consider each in relation to the wider RIS. Because our work is intended as a theoretical contribution primarily, but with an illustrative case to support our arguments, we take the approach in this section of blending our own data and observations with those already contained within the literature. This also matches our methodology described above, where we identified themes and points of interest by working backwards and forwards between data and theory.

Table 3. Data collected.

Methods used	Data collected	Concepts studied
<ul style="list-style-type: none"> • Documentary evidence • Semi-structured and open-ended questionnaire • Observations of innovations • Group discussion • Expert feedback • Telephone interviews 	<ul style="list-style-type: none"> • Public documents, news articles, websites, social media • Open-ended questions sent via email • Observing the technicalities of the innovations in action • Discussions with local users • Gained feedback from researchers, doctors and engineers on the functioning and use of the innovations • Detailed one-hour-long interviews over the phone 	<ul style="list-style-type: none"> • Purpose, motivations, experiences, problems, bricolage, social impact • Constraints, geographical disadvantage • Functioning, energy use, ease of usage, maintenance, limitations • Repurposing, reuse, self-reliance • Standards and technical use, technological disobedience • Context-specific tailor-made solutions to mitigate COVID, the enemies of innovation, regional innovation systems problems

4.1. Constraints, geographical disadvantage and frugality

The case study location dictates a particular context of RIS in an emerging economy, with high levels of poverty. In particular, financial, economic and institutional restrictions are the most common constraints, as other researchers working in similar contexts have found (Agarwal et al., 2016; Bhatti et al., 2018; Nakata & Weidner, 2011). Interestingly, Agarwal et al. (2021) view constraints as the driving force behind generating frugal innovations, especially in resource-scarce contexts. We identified that ex-ante constraints such as COVID-disrupted supply chains, triggered strong motivations to respond with quick solutions amongst Kashmiri innovators.

The innovators were hampered by a lack of institutional support in the wider RIS. Kashmir is a peripheral mountain region. Networking between different innovation actors in the region is quite weak, and extra-regional linkages, for instance, through universities, are weak. We clearly know about the favourable impact of geographical advantages of institutionally thick RISs, in terms of ensuring spillovers with regard to regional characteristics for knowledge and innovation development (Segarra-Blasco et al., 2018). However, our cases show how peripherality is a major source of frugal innovation. A location encircled by the Himalayas with poor surface communication and a hilly, rough road connecting Kashmir to mainland India, combined with a long-running armed conflict between India and Pakistan, both claiming Kashmir, that has claimed over 100,000 lives since 1989, has in some senses benefited frugal innovators. They have adapted to withstand and endure lengthy, hard winters, shutdowns and internet clampdown¹ without relying on outside assistance. This 'disadvantage' according to all the innovators we spoke with is a powerful motivator for them to seek out cost-effective alternatives.

4.2. Culture of reusing and repurposing

Kashmir provides a promising stage for frugal innovation scholars, given the preponderance of grassroots innovations in this region (Muchie et al., 2017; Sheikh, 2019; Sheikh & Bhaduri, 2020). The COVID-19 crisis only served to intensify these trends amongst the regions' inventors. Several of the frugal innovations we identified centre around reusing and repurposing unwanted items and materials. An example of this from our research (case 12) is a ventilator that was assembled using a wiper motor from an old Wagon R car they had procured from a local scrap dealer. The ventilator valves were made out of Coca-Cola bottle lids. The outside box was made from leftover plywood, the pipe connectors were made from Coca-Cola bottles, and the 12 V power supply was from a computer. The extension on the prototype's motor lever was made of scrap steel. Another group of innovators (case 1) designed a prototype for a dual Ambu Bag resuscitator used for supplying oxygen by reusing material such as 11-mm ply sheets, miniature circuit breaker strips, old printer parts, a drafter, motors and

electronics components. To construct transparent splash guards, which were supplied to frontline health workers, two innovators (Azad and Faizan) used old X-ray sheets and transparent file protectors.

Similarly, innovators (case 3) invented a touchless hand sanitiser incorporated an infrared sensor, submersible DC motor pump and power supply assembled using second-hand pipes, empty containers and plastic bottles. One innovator (case 10), who attracted attention from leading media outlets in India, designed a ventilator using a DVD driver from his old central processing unit as a rack and pinion gear coupled with a 12 V motor extracted from his old printer. To change the direction of his ventilator's sliding door, he used spare parts from the power source of his old computer. The electronic circuits of his machine were housed in an old fruit-drying box.² Another innovator (case 6) started distributing face masks which he was manufacturing using old Khadi cloth pieces, aluminium foil sheets and activated carbon which was locally available. This mask was recyclable and easy to prepare.

It is clear from research carried out over the last decade that this culture of reuse and repurposing is not a new phenomenon that emerged during COVID-19 but has been at the heart of frugal innovation culture that has flourished in Kashmir over a longer period (Bhaduri & Sheikh, 2013; Harris et al., 2020). Kashmiri frugal innovators benefitted from a strong culture of reuse and repurpose that is embedded in the regional innovation culture of inventiveness and make do and mend. This culture and tacit knowledge that the region is heavily endowed with proves to be a great resource during the pandemic when rapid and cheap solutions are needed, and the region's residence already has the skills and knowledge on how to repurpose materials effectively in this manner. We cannot claim this as an exclusive regional endowment, since other cases of repurposing were reported worldwide, but it is clear to see the '*jugaad* innovation' culture that is long established in this region paying off. We can link this theme to the broader discussions taking place around the circular economy, and clearly this is a case in point of circular economy in action.

4.3. Local innovators navigating national and international standards

Standards are needed to ensure the performance, conformance, and safety of new products and processes as technologies advance (Utterback, 1994). Standards can play a crucial role in the diffusion of innovations (Blind et al., 2017) both in the local niches and outside the space of origin (Allen & Sriram, 2000). However, the history of inventions also tells us that standards can stifle new innovations by entrenching obsolete technology, increasing resistance to change (Allen & Sriram, 2000). In diverse economies, two types of standards have arisen. De jure standards are those imposed formally by governments, while de facto standards are those that emerge and exist informally inside the sector (Lea & Hall, 2004). In the issue of standards, we see where the RIS, represented in our case by frugal

innovators, comes into contact and conflict with elements of the national and international innovation systems. In India, this issue is managed by the Indian Standards Institution (ISI) and the Bureau of Indian Standards (BIS) (2022). The BIS has more recently started focusing on India's indigenous sectors with 'significant commercial' potential in order to improve its contribution to global standardisation efforts. During COVID-19, the BIS allowed a modification of its in-house testing requirements for PPE, filter masks and eye shields. This exception was granted to speed up the production of these commodities to alleviate the shortage.

However, Indian standards are perceived as stymieing local bottom-up innovations and trying to reconcile the need and value of standards (often at an international level) with frugal innovation is complex. There are many cases where frugal innovations fail to meet the international or national standards. During COVID-19, as we already explained, many bottom-up innovators developed prototypes of ventilators and PPE equipment in Kashmir. As reported to us during data collection, many innovators fail to obtain ethical or technical clearance for animal and other testing trials. Accordingly, they fail to meet the requirements as set by international and national standard organisations, though they produce working prototypes:³

We developed an emergency use ventilator designed to support the standard ventilator modes of operation. ... This was supported by a leading engineering institute. The prototype was working perfectly well and it passed all the initial simulation tests conducted at Kashmir's leading hospital. ... Unfortunately, getting permission to conduct animal and human trials became a hurdle to swiftly design a ventilator for the hospitals. Not receiving the approval on time killed our innovation project.

When people were gasping for air and hospitals were struggling for ventilators, we responded on time with our frugal ventilator design. The same enthusiasm and speed was not visible from the government side.

This unusual delay has demotivated everyone present in the team. Innovators are not happy, people who offered technical and financial support to this project are also discouraged.

Other innovators we spoke to were unaware of the ethical and animal testing clearances needed, standards existing, and how to obtain clearance and support from ethical and standardisation organisations. These issues represent major barriers for the diffusion and wider take up of frugal innovations, and represent a misalignment between different levels of regional, national and international innovation systems (Gupta, 2016).

4.4. Individual innovators connected through social media

Much of the seminal innovation systems work was conducted in the days before the widespread use of social media. What we find in our study is that social media has a crucial role in connecting RISs to national and

international networks of innovators, via the use of social media by frugal innovators. Indeed, the importance of social media to how frugal innovations arose in response to COVID-19 was so strong that we suggest it needs to be further explored in future research to understand exactly how our understandings of innovation systems and their spatiality shifts when we add social media into the mix. We found an interesting and complex interaction in our cases between social media, traditional media and individual innovators, with researchers such as ourselves also sitting within this network, and leveraging both social and traditional media in our methodological approach to finding and accessing frugal innovators.

India has a culture of rewarding and appreciating frugal innovations, and they are a popular topical news item, as some of the links provided in this paper illustrate. This serves to share news about new frugal innovations, which in turn can be copied and adjusted, but also to celebrate innovators and inventors within the culture. We find that positive media responses, and celebrations of innovations by the wider community of users, in turn motivate and fan the flames of innovators' passion and interest. Here we report a good example of this network in action.

On 25 April 2020, the first author of this paper shared a 200-word post on his personal Facebook page to honour an innovator (Jamsheed), a professional shopkeeper from Bandipora-Kashmir. Once a post about his 'automatic body sanitisation' innovation went viral, his innovation became widely appreciated by a diverse public. Numerous media outlets picked up the story and profiled his innovation, turning him into a sort of 'frugal innovation celebrity'. Shortly after the ensuing recognition, Jamsheed submitted another design for an oxygen-pumping machine; the recognition of his efforts spurred him forward and pushed him into becoming a repeat innovator. This recognition happened because of the widespread usage of Facebook, and the links between social and traditional media, where stories get shared and picked up across different venues. Also linked to the previous point about culture, we can see there is something special about the culture around frugal innovation in Indian Kashmir that elevates its innovators and celebrates them as stars.

The role of social media is certainly central in this story, and also links what is happening at the regional level in Indian Kashmir with a global movement of frugal innovation. Zastrow (2020) notes how open science has responded to the pandemic with data sharing, open-source designs and hobbyist innovators. In Kashmir, many of our cases shared ventilator prototypes and explained their machines' functioning on Facebook and YouTube. Their innovations have been discussed in detail and shared by hundreds of site users. Some innovators are using Facebook and WhatsApp to instruct frontline employees and others on creating face shields or masks using locally available materials.

The regional frugal innovation system is heavily reliant on social media interacting with traditional media. For

instance, *Greater Kashmir*, a local newspaper, shared a brief video featuring Kashmir innovations on its Facebook page on 24 April 2020.⁴ Similarly, an innovator (Wasu) shared his innovation with India's leading national daily the *Hindustan Times*, which was picked up internationally by CNN news on 8 June 2020.

This very widespread and rapid sharing of frugal innovations means that the learning and knowledge-sharing process is taking place both within the regional territory, but linked into a national and international network as we describe above. The frugal innovations in our study are both sharing their own designs and also learning from the designs being shared by innovators elsewhere. It has been noted in other contexts that a number of do-it-yourself hobbyists produced many important COVID-19-related equipment using digital fabrication and with minimal resources (Corsini et al., 2021). This surge was triggered partly in response to the failure of the dominant and traditional industry manufacturing model (Pearce, 2020) and partly because people outside formal settings want to co-create solutions not for monetary gain.

This crowdsourcing culture of developing innovative solutions by sharing capabilities and ideas has helped create an important resource to fight COVID-19 (Vermicelli et al., 2021). Open source platforms such as Top Coder and InnoCentive helped create a pool of innovative prototypes. Whilst this is certainly not a phenomenon specific to our regional case of Indian Kashmir, we can clearly see that the frugal innovators in this area have taken on the mantle, and the wider network of social media, traditional media and digital platforms have enabled their innovations to be shared worldwide as well as within the region.

4.5. 'Made in Kashmir': the importance of thinking about frugal innovation from a regional perspective

Mainstream innovation scholarship has focused on exchange value, scalability and large-scale commercialisation, while overlooking the other important pro human-centric values fostered by frugal innovation. As we already explained in the literature review, there has been very little integration of more sociological perspectives on innovation into the regional innovation debates: there has likewise been and underreporting of Global South and emerging economy cases, an issue that has been raised by regional scholars already (Thomas & Pugh, 2020). We respond to the call of regional studies editors to 'push Regional Studies beyond its borders' (Harrison et al., 2020). Many frugal innovations are conceptualised to fill spaces that are underserved by either the state or the mainstream market (Bhaduri & Kumar, 2011), their various pro-social motivations in solving local problems, their role in fostering community relations, individual self-esteem, creating alternative discourses of innovation have received scant attention (Sheikh & Bhaduri, 2020, 2021).

We can see a strong tendency towards regional self-reliance amongst the innovators we spoke to, which sets them in a good position to be frugal innovators.

Self-dependency is a strong trend in Kashmiri culture, due to its history as a landlocked state, with complex geo-politics at play, and a desire to be free from dependency on nearby states for capabilities and resources. This reliance actualises through small and localised forms of technology. This tendency is a wider cultural phenomenon situated within the history of India: Mahatma Gandhi in 1907 prominently spoke out against certain modern technologies which he argued were wielded by the privileged few and neglecting the masses; he maintained that local inventions such as the *charkha* (an Indian spinning wheel) could help Indians extricate themselves from British rule. That is, that the culture of technological self-reliance runs very deep.

The innovators with whom we interacted aimed to create *local* inventive solutions. The 'made in Kashmir' culture was stressed by them all. Kashmiri frugal innovators enacted self-reliance by using the resources at hand: the RIS is rooted in technological self-reliance rather than dependence. India saw COVID-19 as a chance to strengthen its local capabilities and self-reliance. On 12 May 2020, the Prime Minister of India championed the cause by launching *Atmanirbhar Bharat Abhiyaan* (the 'Self-reliant India' campaign) and announced a comprehensive economic package of INR20 lakh crores – equal to 10% of India's gross domestic product (GDP) – to fight COVID-19 in India. The objective of this call was to make 'India and its citizens independent and self-reliant in all senses'. With hindsight, having witnessed the second wave and India's receipt of emergency support from other countries to manage the huge peak in cases and deaths, we perhaps reflect differently on these statements.

But we can see COVID-19 as an example of how relying on a traditional innovation model, whereby the adapting of advanced technologies from elsewhere can run very easily in roadblocks that necessitate a different form of innovation to problem solve in a crisis. Beyond the specificities of this particular case of COVID-19, the process of adopting high-end technology in a poor state is not only expensive and unsustainable but also does little to increase employment. Frugal innovations are generally associated with relatively basic devices often made out of old machine parts, cloth or wood, but more advanced technologies may also be used. As demonstrated by Kashmir's local innovators, simple solutions using locally available materials and local capabilities can create varied forms of value ranging from human-centric values to environmental and social values, and the democratisation of innovation.

5. DISCUSSION: TOWARDS A REGIONAL FRUGAL – INNOVATION SYSTEM (RF-IS)

In this section, we broaden our discussion to address the challenges and opportunities for frugal innovation research going forwards. As previously stated, frugal innovations are context-dependent (Bhatti et al., 2018) and warrant the application of a regional lens to understand how they fit into the established picture we have in the literature of RIS in various regions around the world. There is a

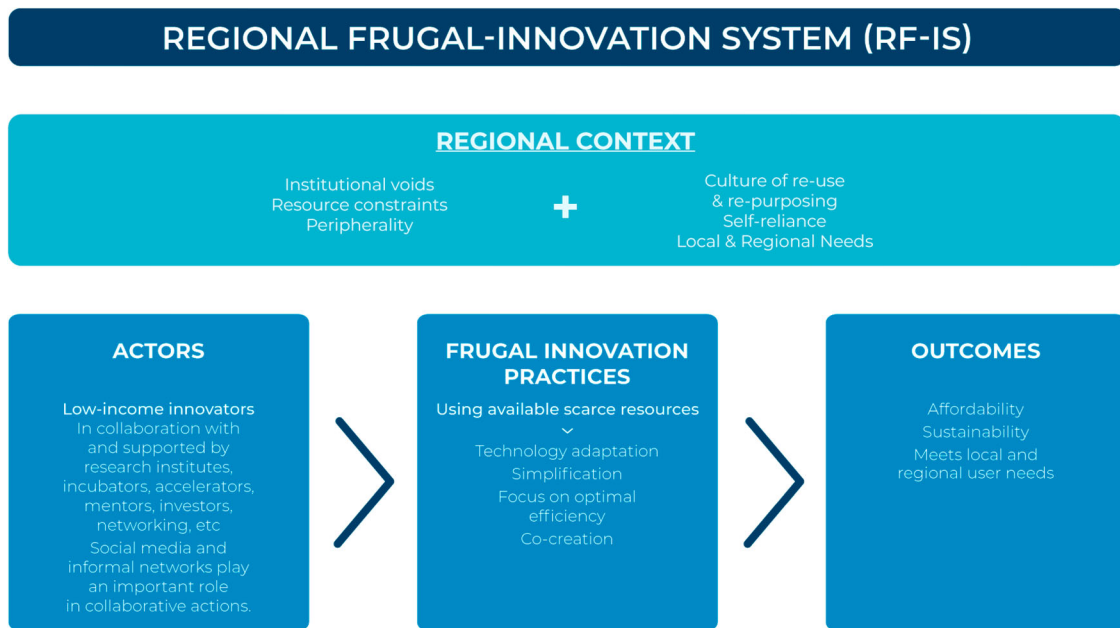


Figure 1. Regional frugal innovation system.

clear need to integrate the studies of regional and frugal innovation, since frugal innovation is the *modus operandi* of a large share of innovators globally.

To tie up our findings of frugal innovation practices in a regional context, we propose a simple framework of a Regional Frugal Innovation System (RF-IS), which plays out in a regional context, serving local needs, and using local and easily available resources, to craft affordable and good-enough products. RF-IS is thus socially and territorially embedded, framed by its institutional and cultural context. Figure 1 presents a succinct RF-IS figure suggesting such a system.

More empirical work on RF-IS is required in different regional settings: in the innovation literature, the bottom-up stories concerning frugal innovations are not well-documented. As a result, a gap has emerged between so-called ‘top-down business and management literature’ on frugal innovation and bottom-up development studies discourses on grass-root innovation, bricolage and livelihood solutions (Leliveld & Knorringa, 2018). To link frugal innovation to development, both narratives are equally significant.

Within the frugal innovation research, the concept of ‘innovation’ needs to be clarified and explained. Almost every study mentions some type of technology that has the potential to disrupt large markets. This is correct to a certain extent, but technological innovation is overvalued (Godin et al., 2021). Frugality also encompasses non-technological and non-artefact-based advances. To understand the underpinnings and nuances of frugal innovations, the alternatives to technology driven innovation merits equal attention.

We have seen that in many settings frugal innovations are being deliberately undervalued, for a variety of reasons ranging from politics to gender to social issues. This is a wider issue in work on innovation and invention, around

who is receiving credit and attention and who is not. For instance, we have seen how African-Americans have been denied credit for their inventions in the US historiography of invention (Fouché, 2006). Mavhunga (2014, pp. 10–14) claims that technology historians have similarly ignored Africa as a source of invention, instead producing histories that support imperial ambitions and racialised caricatures (Irani, 2019). Martin (2016) laments innovation studies’ obsession with ‘boy’s toys’ and certain technologies, whilst ignoring others. It is clear that who is considered an innovator, and what is considered an innovation, is not power neutral (Irani, 2019).

Metrics are another sticking point for frugal innovation scholars (Sharma et al., 2021). Using market-based innovation metrics to assess the efficiency of frugal innovations miss much of their purpose and value. Incentives such as profits, intellectual property rights, etc. are not aligned to the logic of many frugal innovations, which are about solving specific needs in cost-effective ways. How to measure and value is an unanswered question, as is how to collect data (especially quantitative data) on them. Because frugal innovations often rely on informal networks and social media for dissemination, we need to develop new tools and approaches to capture them, as we have illustrated here with our multifaceted case study approach.

6. CONCLUSIONS: THE IMPORTANCE OF A REGIONAL RF-IS FOR SUSTAINABLE FUTURES

We stated at the outset of this paper that RIS work to date has had limited engagement with frugal innovation thinking and perspectives. There are some other concepts that can overlap somewhat with frugal innovation that have been examined from the regional innovation perspective,

such as inclusive innovation, social innovation and informal innovation (Lowe & Wolf-Powers, 2018; Suitner et al., 2022; Thomas & Pugh, 2020).

Through the discussions we present above, we illustrate a so-called ‘regional frugal-innovation system’ in practice, in Indian Kashmir, during the COVID-19 pandemic. Through this moniker we state our ambitions to align the so far quite separate bodies of work on frugal and regional innovation, illustrating from our data how when we unpack frugal innovation it has a distinct regional characteristic and impact. The key elements we zoom in on here – the culture of repurpose and reuse, the use of social media and digital technologies to build a community of innovators both on a regional but also global scale, and the regional self-reliance and ability to adopt and adapt intermediate technologies – are critical for understanding the regional frugal innovation system of Indian Kashmir, and derive wider insights about the importance of frugal innovation as a bottom-up and place based phenomena particularly during crisis periods.

We believe these insights are relevant for all regions during such a crisis period, and not only those in the Global South. Frugal innovation can be relevant for all places, and all actors who are trying to do more with less. In particular, small and micro-businesses spring to mind as actors who could particularly benefit from a closer study of frugal innovation, also in more advanced economies. We are also interested in frugal innovation as a concept that may help increase resilience in poorer regions generally (be they Global North or South), and as a means for delivering more sustainable and inclusive modes of innovation that include more of the needy populations than traditional innovation models have. In particular, the feature of ‘repurpose and reuse’ hold much promise as a model for circular economy development, which is emerging as a very important concept for regional studies scholars (Lever & Sonnino, 2022) and we argue frugal innovation has an important role to play therein.

We have also filled a gap in the extant regional studies literature by placing frugal innovation at the heart of our discussion, and we have proposed the concept of the regional frugal-innovation system as an iteration on the classic concept that the community has been instrumental in developing. We suggest that this RF-IS concept could add a particular relevance and broadening in terms of bringing the cases of Global South and emerging economies regions into the heart of our discussions around regional innovation. There is also a wider discussion to connect to, about sustainable and resilient modes of economic development, which have a relevance and urgency beyond the current pandemic. As supply chains were disrupted due to COVID-19, the innovators we met invented ‘uses’ from items in junkyards. This practice of finding simple solutions to complex problems is as old as human civilisation (Bhatti et al., 2018); however, the discourse on frugal innovation, Gandhian innovations, and grassroots innovations which emerged from India has affordability and sustainability at its core (Gupta, 2016; Prahalad & Mashelkar, 2010). Bottom-up innovations we are witnessing around

the world offer an alternative to innovation models driven by affluence and abundance. COVID-19 has thus opened a window of opportunity to reframe the power of simplicity and local innovations, which will be relevant for us going forwards into the green transition. Frugal innovation offers a path of infusing apparent ‘waste material’ with new value (Sheikh & Bhaduri, 2020).

In so doing, these inventors not only created a circular economy of their own but also developed many non-economic, human-centred values. Use of waste, recycling environmentally unsuitable material and resizing trash rendered these innovations relevant to achieve sustainability (Chen & Liu, 2014). As Gupta (2016) argued, many grassroots innovations are not being valued enough today, but they will do as the sustainability crisis becomes even more profound. In this regard, we see frugal innovation gaining importance as we are necessitated to consider the sustainability dimensions of regional innovation more profoundly. The bottom-up innovations studied here offer a glimmer of hope for reaching a sustainable, inclusive and equitable innovation pathway beyond the pandemic, and we suggest that sharing best practice but also challenges faced in vibrant regional frugal innovation systems such as Indian Kashmir could provide interesting insights for all regions be they in the Global North or South.

ACKNOWLEDGEMENTS

The authors thank the reviewers for their helpful suggestions in the development of this paper, in addition to the Urban and Regional Horizons section editor John Harrison for his support and guidance throughout the process.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

FUNDING

Rhiannon Pugh gratefully acknowledges funding from FORMAS [grant number 2018-01053]. Soumodip Sarkar gratefully acknowledges generic financial support received from the Fundação para Ciência e Tecnologia (FCT) [grant number UIDB/04007/2020].

NOTES

1. See https://www.washingtonpost.com/world/asia_pacific/indias-internet-shutdown-in-kashmir-is-now-the-longest-ever-in-a-democracy/2019/12/15/bb0693ea-1dfc-11ea-977a-15a6710ed6da_story.html/
2. *Hindustan Times*, <https://www.youtube.com/watch?v=wLR0oDZTnow>
3. Quotations are left blind to protect the identities of innovators when making critical comments towards the government.
4. See <https://www.facebook.com/watch/?v=3680618348678691>

REFERENCES

- Agarwal, N., Grottke, M., Mishra, S., & Brem, A. (2016). A systematic literature review of constraint-based innovations: State of the art and future perspectives. *IEEE Transactions on Engineering Management*, 64(1), 3–15. <https://doi.org/10.1109/TEM.2016.2620562>
- Agarwal, N., Oehler, J., & Brem, A. (2021). Constraint-based thinking: A structured approach for developing frugal innovations. *IEEE Transactions on Engineering Management*, 68(3), 739–751. <https://doi.org/10.1109/TEM.2020.3042929>
- Agnihotri, A. (2015). Low-cost innovation in emerging markets. *Journal of Strategic Marketing*, 23(5), 399–411. <https://doi.org/10.1080/0965254X.2014.970215>
- Allen, R. H., & Sriram, R. D. (2000). The role of standards in innovation. *Technological Forecasting and Social Change*, 64(2–3), 171–181. [https://doi.org/10.1016/S0040-1625\(99\)00104-3](https://doi.org/10.1016/S0040-1625(99)00104-3)
- Altenburg, T. (2011). Building inclusive innovation systems in developing countries: Challenges for IS research. In B.-A. Lundvall (Ed.), *Handbook of innovation systems and developing countries* (ch. 2). Edward Elgar.
- Asheim, B. (2012). The changing role of learning regions in the globalizing knowledge economy: A theoretical re-examination. *Regional Studies*, 46(8), 993–1004. <https://doi.org/10.1080/00343404.2011.607805>
- Asheim, B., & Gertler, M. (2005). The geography of innovation: Regional innovation systems. In J. Fagerberg, D. Mowery, & R. Nelson (Eds.), *The Oxford handbook of innovation* (pp. 291–317). Oxford University Press.
- Asheim, B. T., & Coenen, L. (2005). Knowledge bases and regional innovation systems: Comparing Nordic clusters. *Research Policy*, 34(8), 1173–1190. <https://doi.org/10.1016/j.respol.2005.03.013>
- Asheim, B. T., Isaksen, A., & Trippel, M. (2019). *Advanced introduction to regional innovation systems*. Edward Elgar.
- Bailey, D., Crescenzi, R., Roller, E., Anguelovski, I., Datta, A., & Harrison, J. (2021). Regions in COVID-19 recovery. *Regional Studies*, 55(12), 1955–1965. <https://doi.org/10.1080/00343404.2021.2003768>
- Barr, J., Doroshov, D. B., & Montgomery, S. P. (2020). War and pandemics: Catalysts for medical advancement. *Journal of Trauma and Acute Care Surgery*, 89(4), e95–e96. <https://doi.org/10.1097/TA.0000000000002832>
- Bhaduri, S., & Kumar, H. (2011). Extrinsic and intrinsic motivations to innovate: Tracing the motivation of ‘grassroot’ innovators in India. *Mind & Society*, 10(1), 27–55. <https://doi.org/10.1007/s11299-010-0081-2>
- Bhaduri, S., & Sheikh, F. A. (2013). *Measuring informal innovations: Study of grassroots innovation of Kashmir*. Globelics Academy.
- Bhatti, Y., Basu, R. R., Barron, D., & Ventresca, M. J. (2018). *Frugal innovation: Models, means, methods*. Cambridge University Press.
- Blind, K., Petersen, S. S., & Riillo, C. A. (2017). The impact of standards and regulation on innovation in uncertain markets. *Research Policy*, 46(1), 249–264. <https://doi.org/10.1016/j.respol.2016.11.003>
- Bureau of Indian Standards (BIS). (2022). *Annual report*. BIS. <https://www.bis.gov.in/the-bureau/annual-report/>
- Chen, C., & Liu, L. Q. (2014). Pricing and quality decisions and financial incentives for sustainable product design with recycled material content under price leadership. *International Journal of Production Economics*, 147, 666–677. <https://doi.org/10.1016/j.ijpe.2013.04.016>
- Clark, J. (2020). *Uneven innovation: The work of smart cities*. Columbia University Press.
- Cooke, P. (1998). Origins of the concept. In H.-J. Braczyk, P. Cooke, & M. Heidenreich (Eds.), *Regional innovation systems* (pp. 2–25). UCL Press.
- Corsini, L., Dammico, V., & Moultrie, J. (2021). Frugal innovation in a crisis: The digital fabrication maker response to COVID-19. *R&D Management*, 51(2), 195–210. <https://doi.org/10.1111/radm.12446>
- Eisenhardt, K. M. (1989). Building theories from case study research. *The Academy of Management Review*, 14(4), 532–550. <https://doi.org/10.2307/258557>
- Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, 50(1), 25–32. <https://doi.org/10.5465/amj.2007.24160888>
- Fouché, R. (2006). Say It loud, I’m black and I’m proud: African Americans, American artifactual culture, and black vernacular technological creativity. *American Quarterly*, 58(3), 639–661. <https://doi.org/10.1353/aq.2006.0059>
- George, G., McGahan, A. M., & Prabhu, J. (2012). Innovation for inclusive growth: Towards a theoretical framework and a research agenda. *Journal of Management Studies*, 49(4), 661–683. <https://doi.org/10.1111/j.1467-6486.2012.01048.x>
- Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational Research Methods*, 16(1), 15–31. <https://doi.org/10.1177/1094428112452151>
- Godin, B., Gaglio, G., & Vinck, D. (2021). *Handbook on alternative theories of innovation*. Edward Elgar.
- Govindarajan, V., & Trimble, C. (2012). *Reverse innovation: Create far from home, win everywhere*. Harvard Business Press.
- Grillitsch, M., & Nilsson, M. (2017). Firm performance in the periphery: On the relation between firm-internal knowledge and local knowledge spillovers. *Regional Studies*, 51(8), 1219–1231. <https://doi.org/10.1080/00343404.2016.1175554>
- Gupta, A. K. (2016). *Grassroots innovation: Minds on the margin are not marginal minds*. Random House India.
- Haidare, S. (2020, May 20). *Coronavirus: Afghan girls make ventilators out of car parts*. BBC. <https://www.bbc.com/news/world-asia-52738668>
- Harris, M., Bhatti, Y., Buckley, J., & Sharma, D. (2020). Fast and frugal innovations in response to the COVID-19 pandemic. *Nature Medicine*, 26(6), 814–817. <https://doi.org/10.1038/s41591-020-0889-1>
- Harrison, J., Delgado, M., Derudder, B., Anguelovski, I., Montero, S., Bailey, D., & De Propriis, L. (2020). Pushing regional studies beyond its borders. *Regional Studies*, 54(1), 129–139. <https://doi.org/10.1080/00343404.2019.1672146>
- Hays, J. N. (2005). *Epidemics and pandemics: Their impacts on human history*. ABC-CLIO.
- Hoffecker, E. (2018). *Local innovation: What it is and why it matters for developing economies (D-Lab working papers)* (NDIR Working Paper No. 1). MIT D-Lab.
- Iammarino, S. (2005). An evolutionary integrated view of regional systems of innovation: Concepts, measures and historical perspectives. *European Planning Studies*, 13(4), 497–519. <https://doi.org/10.1080/09654310500107084>
- Irani, L. (2019). *Chasing innovation: Making entrepreneurial citizens in modern India*. Princeton University Press.
- Kaplinsky, R. (2018). *Fostering inclusive innovation for sustainable development. Pathways for prosperity* (Commission Background Paper Series No. 9). Oxford.
- Kuo, A. (2017). Harnessing frugal innovation to foster clean technologies. *Clean Technologies and Environmental Policy*, 19(4), 1109–1120. <https://doi.org/10.1007/s10098-016-1304-y>
- Lea, G., & Hall, P. (2004). Standards and intellectual property rights: An economic and legal perspective. *Information Economics and Policy*, 16(1), 67–89. <https://doi.org/10.1016/j.infoecopol.2003.09.005>
- Leliveld, A., & Knorringa, P. (2018). Frugal innovation and development research. *The European Journal of Development*

- Research*, 30(1), 1–16. <https://doi.org/10.1057/s41287-017-0121-4>
- Lever, J., & Sonnino, R. (2022). Food system transformation for sustainable city-regions: Exploring the potential of circular economies. *Regional Studies*, 56(12), 2019–2031. <https://doi.org/10.1080/00343404.2021.2021168>
- Lowe, N., & Wolf-Powers, L. (2018). Who works in a working region? Inclusive innovation in the new manufacturing economy. *Regional Studies*, 52(6), 828–839. <https://doi.org/10.1080/00343404.2016.1263386>
- Lundvall, B. Å., Joseph, K. J., Chaminade, C., & Vang, J. (Eds.). (2011). *Handbook of innovation systems and developing countries: Building domestic capabilities in a global setting*. Edward Elgar.
- Lundvall, B. K. (2011). Notes on innovation systems and economic development. *Innovation and Development*, 1(1), 25–38. <https://doi.org/10.1080/2157930X.2010.551064>
- Martin, B. R. (2016). Twenty challenges for innovation studies. *Science and Public Policy*, 43(3), 432–450. <https://doi.org/10.1093/scipol/scv077>
- Martins, K., Suzuki, J., & Bossaghzadeh, S. (2020). Agglomeration economies, interregional commuting and innovation in the peripheries. *Regional Studies*, 54(6), 776–788. <https://doi.org/10.1080/00343404.2019.1641592>
- Mavhunga, C. C. (2014). *Transient workspaces: Technologies of everyday innovation in Zimbabwe*. MIT Press.
- Melançon, Y., & Doloreux, D. (2013). Developing a knowledge infrastructure to foster regional innovation in the periphery: A study from Quebec's coastal region in Canada. *Regional Studies*, 47(9), 1555–1572. <https://doi.org/10.1080/00343404.2011.626400>
- Muchie, M., Bhaduri, S., Baskaran, A., & Sheikh, F. A. (2017). *Informal sector innovations: Insights from the Global South*. Routledge.
- Nakata, C., & Weidner, K. (2011). Enhancing New product adoption at the base of the pyramid: A contextualized model. *Journal of Product Innovation Management*, 29(1), 21–32. <https://doi.org/10.1111/j.1540-5885.2011.00876.x>
- Nicholls, A., Simon, J., and Gabriel, M. (2015). Introduction: Dimension of social innovation. In A. Nicholls, J. Simon & M. Gabriel (Eds.), *New frontier in social innovation research*. Palgrave MacMillan. https://link.springer.com/content/pdf/10.10579781137506801_1.pdf
- Onsongo, E. (2019). Institutional entrepreneurship and social innovation at the base of the pyramid: The case of M-Pesa in Kenya. *Industry and Innovation*, 26(4), 369–390. <https://doi.org/10.1080/13662716.2017.1409104>
- Padilla-Perez, R., Vang, J., & Chaminade, C. (2009/2011). Regional innovation systems in developing countries: Integrating micro- and meso-level capabilities [2009]. In Lundvall, B. Å., Joseph, K. J., Chaminade, C., & Vang, J. (Eds.), *Handbook of innovation systems and developing countries: Building domestic capabilities in a global setting* (pp. 360–380). Edward Elgar.
- Pansera, M., & Sarkar, S. (2016). Crafting sustainable development solutions: Frugal innovations of grassroots entrepreneurs. *Sustainability*, 8(1), 51. <https://doi.org/10.3390/su8010051>
- Park, H., Lee, M., & Ahn, J. M. (2021). Bottom-up solutions in a time of crisis: The case of COVID-19 in South Korea. *R&D Management*, 51(2), 211–222. <https://doi.org/10.1111/radm.12449>
- Pearce, J. M. (2020). A review of open source ventilators for COVID-19 and future pandemics. *F1000Research*, 9. <https://doi.org/10.12688/f1000research.22942.2>
- Petri, A. E. (2020, March 31). D.I.Y. coronavirus solutions are gaining steam from Ireland to Seattle, makers and engineers are creating open-source versions of much-needed medical equipment. *New York Times*. <https://www.nytimes.com/2020/03/31/science/coronavirus-masks-equipment-crowdsource.html>
- Prabhu, J. (2017). Frugal innovation: Doing more with less for more. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 375(2095), 20160372. <https://doi.org/10.1098/rsta.2016.0372>
- Prahalad, C. K., & Mashelkar, R. A. (2010). Innovation's holy grail. *Harvard Business Review*, 88(7/8), 132–141.
- Radjou, N., & Prabhu, J. (2015). *Frugal innovation: How to do more with less*. Profile.
- Ramadi, K. B., & Nguyen, F. T. (2021). Rapid crowdsourced innovation for COVID-19 response and economic growth. *Npj Digital Medicine*, 4(18). <https://doi.org/10.1038/s41746-021-00397-5>
- Rodríguez, J. C., Navarro-Chávez, C. L., & Gómez, M. (2014). Regional innovation systems in emerging economies: Evidence of system failures for innovation. *International Journal of Innovation and Regional Development*, 5(4–5), 384–404. <https://doi.org/10.1504/IJIRD.2014.064150>
- Sarkar, S. (2021). Breaking the chain: Governmental frugal innovation in Kerala to combat the COVID-19 pandemic. *Government Information Quarterly*, 38(1), 101549. <https://doi.org/10.1016/j.giq.2020.101549>
- Sarkar, S., Waldman-Brown, A., & Clegg, S. (2022). *A digital ecosystem as an institutional field: Curated peer production as a response to institutional voids revealed by COVID-19*. R&D Management.
- Sarkar, S., & Mateus, S. (2022). Value creation using minimal resources – A meta-synthesis of frugal innovation. *Technological Forecasting and Social Change*, 179, 121612. <https://doi.org/10.1016/j.techfore.2022.121612>
- Sarkar, S., & Pansera, M. (2017). Sustainability-driven innovation at the bottom: Insights from grassroots ecopreneurs. *Technological Forecasting and Social Change*, 114, 327–338. <https://doi.org/10.1016/j.techfore.2016.08.029>
- Segarra-Blasco, A., Arauzo-Carod, J. M., & Teruel, M. (2018). Innovation and geographical spillovers: New approaches and empirical evidence. *Regional Studies*, 52(5), 603–607. <https://doi.org/10.1080/00343404.2018.1444273>
- Seyfang, G., & Haxeltine, A. (2012). Growing grassroots innovations: Exploring the role of community-based initiatives in governing sustainable energy transitions. *Environment and Planning C: Government and Policy*, 30(3), 381–400. <https://doi.org/10.1068/c10222>
- Seyfang, G., & Smith, A. (2007). Grassroots innovations for sustainable development: Towards a new research and policy agenda. *Environmental Politics*, 16(4), 584–603. <https://doi.org/10.1080/09644010701419121>
- Sharma, D., Harris, M., Agrawal, V., & Agarwal, P. (2021). Plea for standardised reporting of frugal innovations. *BMJ Innovations*, 7(4), 642–646. <https://doi.org/10.1136/bmjinnov-2021-000710>
- Sheikh, A. F., Bhaduri, S. (2020). Grassroots innovations in the informal economy: Insights from value theory. *Oxford Development Studies*, 48(1), 85–99. <https://doi.org/10.1080/13600818.2020.1717453>
- Sheikh, F. A. (2019). Undervaluation of informal sector innovations: Making a case for revisiting methodology. *African Journal of Science, Technology, Innovation and Development*, 11(4), 505–512. <https://doi.org/10.1080/20421338.2018.1532630>
- Sheikh, F. A., & Bhaduri, S. (2021). Policy space for informal sector grassroots innovations: Towards a 'bottom-up' narrative. *International Development Planning Review*, 43(1), 115–137. <https://doi.org/10.3828/idpr.2019.34>
- Smith, A., Fressoli, M., Abrol, D., Around, E., & Ely, A. (2016). *Grassroots innovation movements*. Routledge.
- Suitner, J., Haider, W., & Philipp, S. (2022). Social innovation for regional energy transition? An agency perspective on transformative change in non-core regions. *Regional Studies*, 1–13. <https://doi.org/10.1080/00343404.2022.2053096>

- Thomas, E., & Pugh, R. (2020). From 'entrepreneurial' to 'engaged' universities: Social innovation for regional development in the Global South. *Regional Studies*, 54(12), 1631–1643. <https://doi.org/10.1080/00343404.2020.1749586>
- Utterback, J. M. (1994). *Mastering the dynamics of innovation*. HBS Press.
- Vermicelli, S., Cricelli, L., & Grimaldi, M. (2021). How can crowdsourcing help tackle the COVID-19 pandemic? An explorative overview of innovative collaborative practices. *R&D Management*, 51(2), 183–194. <https://doi.org/10.1111/radm.12443>
- Vesci, M., Feola, R., Parente, R., & Radjou, N. (2021). How to save the world during a pandemic event. A case study of frugal innovation. *R&D Management*, 51(4), 352–363. <https://doi.org/10.1111/radm.12459>
- Yin, R. K. (1994). Discovering the future of the case study. Method in evaluation research. *Evaluation Practice*, 15(3), 283–290.
- Zastrow, M. (2020). *Open science takes on the coronavirus pandemic data sharing, open-source designs for medical equipment, and hobbyists are all being harnessed to combat COVID-19*. <https://www.nature.com/articles/d41586-020-01246-3>
- Zeschky, M., Widenmayer, B., & Gassmann, O. (2011). Frugal innovation in emerging markets. *Research-Technology Management*, 54(4), 38–45. <https://doi.org/10.5437/08956308X5404007>