

Frugal Innovation & Digital Platforms

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Abstract

This chapter offers an initial exploration of how frugal innovators use platforms. Conceptually, we distinguish between transaction and innovation platforms, and between top-down and bottom-up frugal innovators. We use this conceptualisation to structure our results that are obtained through an extensive desktop research strategy. Our findings unveil that frugal innovators are active on all three investigated subtypes of transaction platforms. Frugal innovations are widely traded on *retail platforms*, offered by top-down and bottom-up frugal innovators, while spare parts are mainly sold on such platforms by top-down actors. *Social media platforms* are deployed by both types of innovators to increase awareness of the existence and functioning of their frugal innovations. *Funding platforms* are mainly important to bottom-up innovators in search of funding. Also, both subtypes of innovation platforms are deployed by frugal innovators, although we also identified access restrictions for these platforms. *Independent innovation platforms* function as a global marketplace for frugal ideas, with multinational enterprises (MNEs) and non-governmental organisations (NGOs) from the Global North on the demand side of these platforms. On the supply side of these platforms, we find NGOs based in the Global South and grassroots innovators. *MNEs-owned innovation platforms* are used to canvass for external frugal innovators. The chapter ends with a broader research agenda.

Key words: Digital platforms; frugal innovation; fourth industrial revolution; research agenda

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1. Introduction

Digital or Fourth Industrial Revolution (4th IR) technologies can significantly lower the costs of innovation and make it easier to flexibly tailor innovations to particular contexts, leading to many more opportunities for frugal innovations (Leliveld & Knorringa, 2018; Altamirano & Van Beers, 2018; and the introduction chapter of this Handbook). As we are in the midst of this 4th IR, it is as yet difficult to grasp all its implications. Still, it seems to be likely that next to these broad-ranging new opportunities for frugal innovations that can contribute to addressing some of the world's most pressing challenges, these new technologies may also enhance inequalities and 'data colonialism' (Couldry & Meijias, 2019), create a 'digital divide' (World Bank, 2016; Ojenpära et al., 2017), and a few lead 'tech' companies may become too dominant in both the economic and political domain (Mann, 2018).

As a modest first step towards exploring the impacts of the 4th IR on the spread and impacts of frugal innovations, this chapter focuses on one of the central concepts in the 4th IR: digital platforms (see table 1). Platforms are a relevant first focus when it comes to investigating 4th IR impacts on frugal innovations for a number of reasons. First, platforms have been regarded as a major enabling technology of the 4th IR (Schwab, 2016; 2017). Secondly, the platform concept encompasses more than only technology (Grabher and Van Tuijl, 2020). New platform business models, like Airbnb and Uber, disrupt incumbent industries (Parker et al., 2016), and "gig-platforms", like TaskRabbit, are used by firms to orchestrate independent micro-workers instead of hiring protected employees, thus challenging existing labour frameworks (Davis, 2015; Frenken et al., 2020). Moreover, platform "giants" like Alphabet, Amazon, Facebook (now Meta) and Alibaba are not only among the firms with the highest market capitalization, but also challenge existing competition and privacy regulations (Kenney and Zysman, 2020). Finally, labels such as "Platform Economy" (digitally enabled activities in business, politics and social interaction) (Kenney and Zysman, 2016) or "Platform Society" (platforms as infrastructures to shape public values) (Van Dijck et al., 2018) confirm that platforms are not simply a technological innovation but an integral example of how the 4th IR is changing the logics of business models and forms of socio-economic organization.

Concretely, the aim of this chapter is twofold: to explore how frugal innovators use platforms, and to launch a broader research agenda on frugal innovation in the era of the 4th IR. In section 2 we distinguish between two main types of platforms, "transaction platforms" and "innovation platforms" (Evans & Gawer, 2016), and two main types of frugal innovations, top-down and bottom-up (Leliveld & Knorringa, 2018). Section 3 describes our data collection strategy, and section 4 presents our initial results on how frugal innovators use the two platform types. The last section (5) concludes by summarizing and discussing the main findings, identifying next steps to deepen our analyses of frugal innovation and platforms, and it offers some first steps towards a broader research agenda.

Table 1: Role of platforms in 4th IR technologies

| 4th IR technologies | Role platforms | Examples |
|------------------------------|--|---|
| 3D Printing | To demand for and supply of 3D printing services. | 3D Hubs Shapeways |
| Big Data | To collect and analyse data | Android Google Maps |
| Internet of Things (IoT) | To connect machines and systems in order to deliver new products and services | Bosch IoT Suite GE Predix Platform |
| Artificial Intelligence (AI) | To collect and analyse data in order to develop new algorithms to further develop AI | Microsoft Azure Machine Learning Google Cloud Prediction API |
| Robotics and Automation | To connect robots to other machines and larger industrial systems. | GE Predix Platform Siemens Mindsphere |

Source: Own elaboration. Categorization based on Schwab 2016 and ADB, 2017¹

2. Typologies of platforms and frugal innovations

2.1 Transaction and innovation platforms

Platforms in a generic sense refer to programmable digital infrastructures, operated by platform firms, that are designed to intermediate social and economic interactions (Grabher and Van Tuijl, 2020; Kenney & Zysman, 2016). There is a wide diversity of platform types. For instance, when defined by domain, there are platforms for: retail (e.g. eBay), mobility (Uber), labour services (Upwork), funding (Venture Capital for Africa, VC4A) and social networking (Facebook) (Langley & Leyshon, 2017). Platforms may evolve over time and become more diverse. M-Pesa, for example, has evolved from a mobile payment infrastructure into a wider platform that also intermediates other services, such as agricultural micro-insurance or a market access services for small farmers (Altamirano & Van Beers, 2018). Despite this wide diversity and the existence of hybrid types (Cusumano et al., 2019), there are two main types (Evans and Gawer, 2016) following different conceptualizations of platforms within economics and management studies (Thomas et al., 2017).

Transaction platforms connect otherwise fragmented groups of consumers and/or firms (Evans & Gawer, 2016), and function as digital markets in various domains, including markets for goods (e.g. Amazon), social media (Youtube) or accommodation (Airbnb) (Langley & Leyshon, 2017). Transaction platforms are conceptualized in economics as two or multi-sided markets in which the platform functions as an intermediary between two or more groups of market actors. The core principle of multi-sided markets is to generate network effects by matching various market actors with each other (Rochet & Tirole, 2003). This means that the more demand-side users (i.e. Uber passengers) are active on a platform, the more supply-side users (i.e. Uber drivers) are attracted to the platform, which in turn makes the platform more attractive to demand-side users (Parker et al., 2016). The total value of platforms increases with the number of users on both sides as more users imply higher chances of a good match (Rochet and Tirole, 2003).

¹ We removed the 4th IR categories "nanotech" and "biotech", as these are not directly based on digital technologies, in contrast to the other categories.

Platform firms are commercial intermediaries that orchestrate interaction and participation on transaction platforms (Evans and Schmalensee, 2016; Grabher and Van Tuijl, 2020). They control platform entrance by means of participation fees or by requiring platform users to invest in certain software types (Parker et al., 2016). Platform firms also affect the volume of transactions via a cross-subsiding strategy by charging a higher fee for one side of the platform (the "profit-side") in order to subsidize participation on the other side (the "loss-side"), where users can join for a lower price or even for free (Rochet & Tirole, 2003). For instance, sellers on retail platforms often pay a commission, whereas buyers can participate for free (Evans & Schmalensee, 2016). Furthermore, platform operators through both codified Terms-of-Use agreements as well as through black-boxed algorithmic governance and police quality standards and platform interaction (Van Dijck et al., 2018; Zuboff, 2019; Grabher and König, 2020). For instance, Uber uses algorithms to decide which car is being sent to which customer (Reimers et al., 2019), and to block drivers that repeatedly fall under a certain quality level in the perception of users offering reviews (Cockaye, 2016).

Innovation platforms are conceptualized within management studies as platform ecosystems. This platform type provides a standard technology and distribution system to which a large number of external innovators can add complementary ideas, products and services (Gawer & Cusumano, 2014). Complementarity between various products and services is the key logic of such platforms (Teece, 2018). Complementary innovators can "be everyone, and anywhere in the world" and complementary innovators and the platform firm jointly form the platform ecosystem (Evans & Gawer, 2016: 6). One example is Microsoft's Windows ecosystem, which offers a large number of complementary products to Windows software. These products are produced by separate complementary hardware producers (of things like keyboards) and by providers of training and maintenance services (Evans & Schmalensee, 2016).

Platform ecosystems have been used as important elements in open innovation strategies (Chesbrough, 2003), but the degree of openness differs, depending on the "openness" strategy used by platform firms. For instance, Haier, on its HOPE Platform, ranks interested outsiders and allocates them rights with different levels of access to the platform. In later phases, invited users can submit proposals, and when accepted they earn access to more parts of the platform and ultimately win agreements to formalise cooperation on behalf of implementing proposed ideas (Wang & Islam, 2017). In the end, value generation and capturing on platforms requires a mix of openness (to attract users) and a degree of control (to avoid conflicts between users) (Teece, 2018; Schmeiss et al., 2019).

In short, we distinguished between transaction platforms where users can directly interact with each other to trade products and innovation platforms where users co-create innovations. The two types of platforms display partly similar characteristics, as both aim to generate network effects (Thomas et al., 2014), and platform firms of both types are powerful non-neutral intermediaries that orchestrate interaction on and access to their platforms (Evans & Schmalensee, 2016; Grabher and Van Tuijl, 2020).

2.2 Frugal innovation: top-down versus bottom-up

For a typology of frugal innovation, we use the widely used distinction between top-down and bottom-up frugal innovations. Top-down frugal innovations are typically developed by large (international) companies that strip down, re-engineer existing products or develop new innovations to penetrate so-called "Base of the Pyramid" market segments. In contrast, bottom-up frugal innovations are creative practices by people in poor communities who use predominantly locally available means to overcome acute constraints in their survival and livelihood strategies (Leliveld & Knorringa, 2018). Several hybrid types of frugal innovators exist, like social entrepreneurs and non-governmental organizations (NGOs). For the sake of clarity for this initial analysis we define social entrepreneurs and transnational NGOs who are based in the Global North and develop frugal innovations for (poor) communities in the Global South as top-down innovators. In contrast, we label them as bottom-up when the social enterprise or NGO is based in the Global South and innovators develop frugal products for their own community or for communities in their direct surroundings.

3. Research method

We have used an extensive desktop research strategy to identify examples of frugal innovation products and spare parts traded on transaction platforms; and we searched for examples of frugal innovation challenges on innovation platforms. For the analysis of transaction platforms we prepared a list of frugal innovations and a list of transaction platforms consisting of the following subtypes: *retail*, *social media* and *funding platforms*. For our exploration of innovation platforms, we distinguished between the following subtypes: *Multinational Enterprise (MNE)-owned innovation platforms*, operated by MNEs to find external innovation partners who are capable of solving concrete innovation challenges identified by the MNEs; and *independent innovation platforms* that connect demand for and supply of innovation challenges without direct own involvement of the platform firm in the innovation process. We screened both subtypes of innovation platforms for a number of key words. Even though many innovation platforms turned out to be "closed" (i.e. required subscriptions, entrance fees, etc.), which restricted our search, we did obtain some interesting examples of frugal innovation challenges.

Table 2 depicts the overview of search criteria as well as the lists of analysed products and platforms. The key words and the list of frugal innovation products are based on scanning cases mentioned in systematic literature reviews on frugal innovation (i.e. Pisoni et al., 2018; Hossain, 2018), examples frequently used by frugal innovation gurus Jadeep Prabhu and Yasser Bhatti, and examples mentioned on the websites of Delft Global Initiative (www.tudelft/global/) and the International Centre for Frugal Innovation (www.icfi.nl). While searching for these already known examples of frugal innovation products, we also included similar products with similar characteristics that were offered by other entrepreneurs. The lists of platforms were set up by the first author, who has a longstanding interest in platform research. During the search process the lists of platforms and products were inductively extended.

Table 2: Search criteria, analysed products and platforms

| | |
|-----------------------------------|--|
| Search criteria | Low-cost, urgency, resource-constrained, sparing, saving, affordable; affordability, stripping down, good enough; adaptation; user-needs; developing countries |
| Frugal innovation products | J&K Walnut Cracker, Mitticool fridge, WakaWaka solar charger, Tata Nano car, Tata Swach water purifier, GE Max 400 Portable electrodiagram, Nokia1100 phone, Solar home systems or mini-grids, Embrace infant warmer, aQysta hydro-powered irrigation pump, Haier portable washing machine Toyola charcoal stove, Adapt housing, Wonderbag potable cooker, Moladi housing, My-Pad menstruation pad, Bullet-Santi multi-purpose farming device, Decentriq water ATMs, Piramal Sarvajal water ATMs, WakaWaka solar charger |
| Transaction platforms | |
| <i>Retail</i> | Alibaba, Amazon, Bol.com, Craigslist, e-Bay |
| <i>Social media</i> | Facebook, YouTube |
| <i>Funding</i> | Kickstarter, Kiva, VC4A |
| Innovation platforms | |
| <i>Independent</i> | First Build, Herox, IdeaConnection, Innocentive, Kaggle, Mindsumo, Nine Sigma |
| <i>MNE-owned (MNE)</i> | Henri (Neslé); HOPE (Haier), P&G Connect & Develop (P&G), Trusted Network (Beiersdorf), Unilever Foundry (Unilever) |

In the next section, we present our results, structured along the two main types of platforms and the two types of frugal innovators.

4. Results

4.1 Transaction platforms

The upper part of table 3 shows the results of how frugal innovators use transaction platforms, structured along the three subtypes of transaction platforms. As expected, top-down frugal innovators use *retail platforms* to sell products, like Tata that sells its Swach water purifier on Amazon and uses eBay as a place to sell merchandise (i.e. T-shirts). Furthermore, top-down frugal innovators supply spare parts on retail platforms. One illustrative example is Haier, which supplies spare parts, like drains and valve inlets, for its portable washing machine on Amazon. Similar products can also be found on eBay, but then as second-hand products offered by consumers. Likewise, spare parts for the GE Mac 400, like batteries and cables, have been offered on Amazon and eBay by producers of spare parts (e.g. battery producer Cameron Sino) or by specialized distributors (e.g. WorldSupplyMed), selling original branded products as well as non-branded alternatives. Bottom-up frugal innovators also seem to have discovered transaction platforms as new global marketplaces for selling their products to consumers in different continents, as illustrated by Mitticool (supplied on eBay, Alibaba, Amazon), Wonderbag (on Amazon, eBay) and Moldi housing (on Alibaba). Taken together, retail platforms enable consumers to obtain new products (from top-down as well as bottom-up innovators) and spare parts (mainly from top-down frugal innovations) directly from the original producer or from other consumers without the involvement of intermediaries. Moreover, we have also found intermediaries, like sales agents or distributors (e.g. MediSupplyMed), who use transaction platforms as sales channels.

Our results unveil the importance of *social media platforms* for frugal innovations, as nearly all of the products we analysed can be found on Facebook and YouTube. Large top-down frugal innovators use social media platforms as direct or indirect "advertisement space", like Tata showing Nano car commercials on YouTube. We have also found that consumers can upload commercials of top-down frugal innovation products on social media platforms, like a consumer who uploaded a commercial of the GE MAC 400 on YouTube with the post "*Filmed in India rural site. A humorous approach to promoting early health*".

Social media platforms have also been used by top-down frugal innovators and consumers to explain how products function. For example, a Canadian consumer explains how to (dis)connect the Haier washing machine on YouTube, the aQysta hydro-powered water pump has been detailed by its frugal innovators on YouTube and the Embrace infant warmer has been promoted on YouTube as well as on Facebook. Products of bottom-up frugal innovators have also been widely demonstrated on social media platforms. Take Indian water ATM suppliers Primal Savarajal and Decentriq Technologies, with their own Facebook sites and documentaries on YouTube. Another example is Mitticool, which has its own YouTube channel with videos demonstrating its clay fridge model as well as other 'video brochures' displaying the product assortment of Mitticool with contact details. Its Facebook page also functions as a brochure and online shop where consumers can order Mitticool products. A final example is the grassroots social enterprise Goonj, which uses Facebook, YouTube and the platform Slideshare to post instruction videos and slide presentations on how to produce sanitary MYpads from old textiles: "*Here's a simple 5 step process of making MY Pads; 1. Sorted cotton cloth is soaked overnight and washed in washing machines two times. ... 5. A set of 15 MY Pads are inserted into a cloth pack together with a small pictorial leaflet highlighting some simple do's and don't around washing, drying, storing and disposal.*"

Thus, social media platforms are important channels for potentially upscaling frugal innovations, as they are used to explain how products work, and sometimes directly for sales. Moreover, we have observed a diversity of actors discussing frugal innovation products on social media platforms, covering not only frugal innovators themselves and consumers, but also government agencies (e.g. the Indian National Innovation Foundation shows products of award-winning frugal innovators on YouTube, such as the walnut cracker by Mushtaq Ahmed Dar or the Bullet Santi by Mansukhbhai Jagani) and "traditional" media companies (like the BBC and PBS NewsHour with a newsflash on the water ATMs in India). Finally, we found some hints that transactions may take place through these channels, as becomes clear from reactions posted under Facebook messages and YouTube videos. For instance, under a Bullet Santi video on YouTube, we found reactions, such as "Call me, want to purchase" and "price?". In other cases, the benefits of social media platforms to frugal innovators might be questionable due to an amateurish use; Moldi housing, for instance, uploading a video on YouTube without sound.

Funding platforms are relevant in nearly all stages of frugal innovation projects, which becomes clear from the example of WakaWaka. This Dutch top-down based social entrepreneur (successfully) obtained various rounds of funding via Kickstarter for: product development (i.e. tooling and design); conducting field tests in Africa; purchasing components; and launching local manufacturing in Haiti. Furthermore, in

one of its "calls for funding", WakaWaka stated that any money left over will be used to set up local distribution networks and develop new products. The key ambition in all WakaWaka's calls for funding is to lower costs for the final product, and is hence clearly targeted at scaling up its production volumes. Funding platforms are also used by bottom-up frugal innovators. For instance, an entrepreneur from Egypt searches for partners and mentors via VC4A to start a water purifying project, whereas Cobitech Solar and Ecoenergy Solar Home System try to obtain funding via VC4A as well as Kiva to start installing solar-powered off-grid systems. Furthermore, local communities use funding platforms in order to finance the purchase of frugal innovation products, as illustrated by two Kenyan women asking for small loans (500 USD) on Kiva to buy charcoal stoves. This latter example illustrates not only the potential value of funding platforms to frugal innovators in obtaining small and medium-sized loans (Heilbron et al., 2017), but also their potential value in strengthening demand for frugal innovations.

To conclude, our results unveil that all three subtypes of transaction platforms are relevant to frugal innovation. Both top-down and bottom-up frugal innovators sell frugal innovations through retail platforms, while spare parts are mainly sold on platforms by top-down frugal innovators. Social media platforms are used by both types of frugal innovators to increase awareness for their products and to explain how their products function. An issue for our future research agenda is to investigate how social media platforms might play a key role in scaling up frugal innovations. Funding platforms, finally, have been used in all phases of frugal innovation trajectories, as mainly indicated by the top-down example of WakaWaka. In addition, bottom-up actors use funding platforms to access frugal innovation products and to fund frugal projects.

4.2 Innovation platforms

The bottom part of table 3 shows the results of how the two subtypes of innovation platforms have been used for frugal innovation. The ***independent innovation platforms*** present themselves using slogans like "the global pioneer in crowdsourced innovation" (Innocentive) or "meet brilliant experts worldwide" (Innoget). These platforms mainly seem to focus on innovation challenges dealing with basic research or advanced engineering, like "keeping plastics out of the ocean" or "making sustainable chemicals with corn" (examples from Ninesigma) or in specific niches (e.g. Mindsumo is an innovation platform for "Millenials and Gen Z"). Thus, at first sight, independent innovation platforms seem to have limited relevance to frugal innovation.

Nevertheless, at Innocentive and Firstbuild, we found clear indications that independent innovation platforms can be used for frugal innovation as well. For instance, the Humanitarian Innovation Fund (HIF) posted innovation challenges on Innocentive dealing with topics like the development of "scalable, easy-to-use, low-cost, injection device concepts" or low-cost latrine lights in refugee camps. Another example that illustrates the search for frugal solutions in an innovation challenge posted by the HIF is: "a simple, efficient, and durable incinerator that is safe to operate and affordable in low-middle income countries. The design must be lightweight and easy to transport and assemble, or built on-site with accessible skills and materials". Similarly, the Rockefeller Foundation has used the solver community on Innocentive to find frugal solutions, like the development of a solar-powered device to prevent the spread of malaria. The Rockefeller Foundation explicitly addressed the need to find low-cost solutions that can be scaled up easily, like their challenge to redesign a pin pulveriser:

"The challenge is to adapt a specific milling machine so that it will grind materials with a higher moisture and oil content into a similar fine form as well as continue to be able to grind the dry grains as needed. The cost must be kept to a minimum so it is affordable to all". A final example is a private individual in Silicon Valley who uses Firstbuild to obtain further ideas and funding to develop a "low-cost, low-power (human powered, with assisted by a low-power motor) portable washer".

In addition to finding examples of Western NGOs and foundations using independent innovation platforms to post challenges to find frugal solutions in development aid, we also found an example of a commercial firm using Innocentive to find frugal solutions. Car maker Ford has used this independent innovation platform to find innovators to "create accessories for parked commercial vehicles" in Johannesburg, South Africa. The idea of this challenge is to use parked vehicles as "temporary service centres", offering services like prenatal care or education. Ford explicitly requests a solution that fits local conditions and can be used in other urban environments in Africa. This might indicate that Ford intends to scale up the project, but it remains unclear whether this project will be part of a commercial or Corporate Social Responsibility (CSR) activity. Nevertheless, the example illustrates that large profit-oriented firms sometimes also use independent innovation platforms to search for frugal ideas.

While top-down frugal innovators post and fund frugal innovation challenges on independent innovations platforms, we have found limited evidence of bottom-up actors doing this. An exception, though, is the NGO Asset Foundation India that has used IdeaConnection for the challenge of developing "a solar-powered wireless router". This challenge explicitly stressed the "use of cheap materials" and the target of using the router to "offer IT opportunities to children in the developing world". Apart from this exception, we have no evidence that bottom-up frugal innovators in the Global South post challenges on independent innovation platforms, which might be explained by the lack of funding faced by these actors. Nevertheless, grassroots frugal innovators from the Global South can benefit from these types of platforms by responding to challenges put forward by top-down actors. For instance, GOONJ won \$5,000 for its MY-PADs project in an innovation competition on IdeaConnection.

MNE-owned innovation platforms have been set up to obtain access to external innovation sources, as becomes clear from phrases like "for partnering with start-ups to accelerate innovation on a global scale" (Unilever Foundry), "In an increasingly connected world, the biggest business wins come from working together" (P&G Connect + Develop), and "the world is our R&D centre" (Haier's HOPE platform). Innovation challenges on these types of innovation platforms can be roughly divided into three analytically separate categories. The first category relates directly to the core business of the owner of the platform. For example, P&G, a large producer of consumer products, has dedicated its Connect + Develop platform to innovation challenges in fields like "oral, personal and family care innovations" and "household care innovations", and mostly deals with basic research challenges. The second category of innovation challenges targets value chains - e.g. challenges such as a "packaging innovation" (P&G Connect + Develop) or "supply chain - honing operational efficiency and improving transparency" (Foundry) - or the development of new business models. An example of the latter is Unilever, another large consumer goods producer, that asks for new business models in the area of business-to-consumers. The third category concerns "grand sustainability challenges", as put out by the HENRi platform of Nestlé

(a large food and beverage processor) and by Unilever's Foundry. A concrete example of such a challenge on HENRi is "Nesquik Studios". The goal of the Nesquik Studios challenge is to develop an online forum and development lab geared towards creating new games where kids re-discover outdoor play, in order to promote a more active and healthier lifestyle.

The analytically distinct three types of innovation challenges – to dynamize MNEs' core business and their value chain interactions and address "grand sustainability challenges", would imply that MNE-owned platforms are of limited relevance to frugal innovation. However, we identified explicit canvassing for frugal solutions under the label of addressing the "grand sustainability challenges". For instance, on the Foundry platform, Unilever searches for start-ups to "solve the global water crisis" so as to "secure access to clean, affordable drinking water for everyone on Earth". One of the start-ups supported on Foundry is Altered, which has developed a fit-on faucet at the end of taps as a simple solution for conserving water use in everyday practices like hand washing. In another challenge, Unilever supports a French start-up that has launched Cowash, an app that enables consumers to share laundry services. Cowash is promoted as "an affordable digital laundry service designed to build social links and community". Nestlé, as well, searches for frugal solutions on its HENRi platform, as, for instance, becomes clear from a challenge aimed at developing a new concept to diagnose micronutrient deficiencies. Nestlé explicitly requires the concept to "be non-invasive, scalable, cost efficient and able to provide instant results. To make the service or tool as accessible as possible, it should also be easy to use, compact and portable". As such, Unilever and Nestlé use their innovation platforms to obtain access to frugal ideas. The strategic intent behind these initiatives and the extent to which they actually deliver on 'grand challenges' will be part of our future research agenda.

Finally, we have identified two barriers that may hinder frugal innovators in using innovation platforms. First, independent innovation platforms do ask a fee. For instance, HeroX takes fees of 18% (for challenges with prize values of up to \$250,000), 14% (for prize values between \$250,001 - \$1M) or 10% (for prize values of \$ 1M and more). Such fees may deter frugal innovators with limited budgets – grassroots innovators in particular – from searching for ideas and partners on innovation platforms. Secondly, various innovation platforms require a subscription to obtain access to the details of the challenges posted. For instance, this was the case on the independent innovation platform Idekan, as well as the MNE-owned platforms of GE Innovation Lab, Haier's Open Innovation Platform and Beiersdorf's Trusted Network. Such subscription systems do not only increase search costs for frugal innovators scanning for new ideas and partners, but may also exclude those who are not able or willing to subscribe to platforms, for instance for privacy reasons or for a fear of data leakage.

To summarize, both independent and MNE-owned innovation platforms are used by frugal innovators. Independent innovation platforms in some cases function as a global marketplace for frugal ideas, with MNEs and NGOs from the Global North on the demand side of these platforms, in search of frugal ideas. On the supply side of these independent innovation platforms we find NGOs based in the Global South and grassroots innovators as the suppliers of frugal solutions. MNEs-owned innovation platforms are used to canvass for external frugal innovators. MNEs fund these external innovators and selectively incorporate the ideas provided by them into their own innovation processes. Finally, we found that a variety of access restrictions may hinder

frugal innovators, especially the smaller and more informal ones, in using independent and MNE-owned innovation platforms.

Table 3 Results

| | | Platform usage for frugal innovation | Top-down examples (platform) | Bottom-up examples (platform) |
|-----------------------|------------------------|--|---|---|
| Transaction Platforms | Retail platforms | Trade of final products | Tata Swach (Amazon) WakaWaka (Bol.com) Tata Nano (Alibaba) | Mitticool (eBay, Alibaba, Amazon) Wonderbag (Amazon, eBay) Moldi housing (Alibaba) |
| | | Trade of spare parts | Haier Washing Machine (eBay, Amazon) WakWaka solar charger lamp (Alibaba) GE Mac 400 (Amazon, Alibaba)t | - |
| | Social media platforms | Increase awareness and advertisements | Tata Nano (YouTube) GE Mac 400 (YouTube) | Mitticool (Facebook) |
| | | Product explanation | aQysta irrigation pump (YouTube & Facebook) Customer review of Tata Nano (YouTube) Embrace Little Lotus infant warmer (YouTube) | Mitticool (Facebook) Bullet-Santi (YouTube) Primal Savarajal water ATMs (Facebook) Decentriq Technologies Water ATMs (Facebook, YouTube) Mushtaq Ahmed Dar J&K Walnut cracker (YouTube, Facebook) Wonderbag (Facebook, YouTube) Moldi housing (YouTube, Facebook) Goonj My-Pad (Facebook, YouTube) |
| | Funding platforms | Innovation partner search | - | Local entrepreneur from Egypt asks for partners and mentors for a water purifying project (VC4A) |
| | | Prototype development | WakaWaka (Kickstarter) | - |
| | | Field test | WakaWaka (Kickstarter) | - |
| | | (mass) production | WakaWaka (Kickstarter) | Cobitech Solar (VC4A) Ecoenergy Solar home System (Kiva) |
| | | Local distributors search | WakaWaka (Kickstarter) | - |
| | | Purchase of frugal innovation products for local communities | - | Two Kenyan women want to buy charcoal stoves (Kiva) |

| | | | | |
|----------------------|----------------------------------|--|--|---|
| Innovation Platforms | Independent innovation platforms | Search for frugal ideas | <ul style="list-style-type: none"> - HIF: i) frugal incinerator, ii) frugal injection device, iii) latrine lights in emergencies (Innocentive) - Rockefeller Foundation: i) pin pulveriser redesign, ii) solar powered device to prevent spread of malaria, iii) rainwater harvesting storage tank (Innocentive) - Private person from Palo Alto: low-cost, low-power, portable washer (Firstbuild) - Ford: commercial vehicles redesign (Innocentive) | <ul style="list-style-type: none"> - GOONJI: My Pad (IdeaConnection) - Asset Foundation India: solar-powered wireless router (ideaConnection) |
| | MNE-owned innovation platforms | To search for and fund external innovators with frugal ideas | <ul style="list-style-type: none"> - Altered's water-tap device (Unilever Foundry) - Cowash shared laundry wash (Unilever Foundry) - Vitamin D check concept (Nestlé HENRi) - Diagnose micronutrient deficiency concept (Nestlé HENRi) | Not applicable |

5. Conclusions and steps towards a research agenda

This chapter offers an initial exploration of how frugal innovators use platforms to trade their products and to co-create new innovations. This final section concludes by summarizing our main findings, identifying next steps to deepen our analysis of the impact of platforms on the spread and impact of frugal innovations and offering some first steps towards formulating a broader research agenda on frugal innovation in the era of the 4th IR.

5.1 Initial main findings

We distinguish between transaction and innovation platforms, and between top-down and bottom-up frugal innovators. Both types of frugal innovators are active on both types of platforms, and section 4 provides an overview of illustrative cases (see also the summary in table 3). The main finding regarding transaction platforms is that frugal innovators are indeed active on all three subtypes investigated: retail, social media and funding platforms. A wide variety of examples of frugal innovation products are traded on retail platforms, offered by both top-down as well as bottom-up frugal innovators. Moreover, 'frugal' spare parts are a booming business on retail platforms. Social media platforms offer a wide range of videos and posts to increase awareness of the existence and functioning of frugal innovations, supplied by both top-down and bottom-up innovators. Funding platforms were found to be important to bottom-up innovators in search of funding for their innovation processes and avenues for bringing innovations to the market.

The main finding regarding innovation platforms is that while these are primarily geared towards high-end sophisticated innovations, they also contain clear examples of firms searching for frugal innovators as external partners. Humanitarian aid agencies and MNEs put 'innovation challenges' on independent innovation platforms to find partners that can address 'grand challenges' through frugal innovations. Grassroots innovators in the Global South and NGOs from the Global North do react to these challenges and use independent innovation platforms to access funding to develop and scale up their innovations. In turn, MNEs use their own innovation platforms to search for external innovators to co-develop frugal solutions to address 'grand challenges'.

5.2 Next steps for empirical research on digital platforms and frugal innovation

Our initial findings provide plenty of inspiration to develop a more rigorous empirical research agenda that moves from collecting illustrative examples to asking 'how' and 'why' or 'why not'. Two follow-up research issues stand out. First, social media platforms play a potentially very important role in mobilizing interest in developing and using frugal innovations. How is this developing, who is taking the lead and who benefits? What kind of information is shared or not shared on social media platforms, and why? Secondly, innovation platforms offer great potential for polycentric co-creation of frugal innovations. It will be of key importance to empirically examine why and how MNEs invest in co-created frugal innovations, to what extent they make a real dent in addressing 'grand challenges' and how 'sub-contracted' external bottom-up frugal innovators will benefit.

Moreover, the initial desktop research leads to the following lessons for future work. First, we only covered a limited number of rather well-known generic platforms, which can be extended in a next phase. Moreover, it might be worthwhile to examine whether some platforms display more frugal characteristics themselves, and whether that also attracts more ‘traffic’ from frugal innovators. Secondly, while our desktop approach proved useful for obtaining initial findings on the importance of platforms for frugal innovation, it is also clear that doing primary interviews with platform firms as well as users is a necessary and important part of a future research agenda. Thirdly, we will revise our frugal innovator typology. Systematic similarities were found among social entrepreneurs and NGOs, irrespective of whether they belonged to the Global North or the Global South. Therefore, following Knorrinda and Bhaduri (2019), we propose moving from the top-down versus bottom-up classification towards a three-tiered classification of: i) profit-oriented firms; ii) social enterprises and NGOs; and iii) local community-based innovators in the Global South. Fourthly, our study focused on tangible products with frugal characteristics. Arguably, frugal services might be at least as prevalent as tangible products, take for instance financial, healthcare and educational services that are also offered through platforms, as discussed in key works in the platform (e.g. Van Dijck et al., 2018) as well as in the frugal innovation literature (e.g. Radjou & Prabhu, 2015). It would also be worth investigating to which degree platforms themselves – as a service - can function as a frugal solution in resource-constrained settings. This touches upon a more generic discussion about the socio-economic effects of platforms, which is discussed briefly below as part of a more generic future research agenda on frugal innovation and the 4th IR.

5.3 Towards a ‘frugal innovation and the 4th IR’ research agenda

Our ambition is to build a research agenda on how the 4th IR influences the development, scaling up and impacts of frugal innovations. We are particularly interested in where and when the 4th IR is more likely to offer opportunities for developing and scaling up frugal innovations that can contribute to addressing global ‘grand challenges’. Such an ambitious agenda requires a balanced approach in terms of investigating both the opportunities as well as issues of power and exclusion, as can be found in the emerging literature on the implications of new digital technologies for sustainable development (e.g. UNCTAD, 2017; TWI2050, 2019; Sturgeon, 2019), and in the more specific literature on platform capitalism and its impacts (i.e. Srnicek, 2016; Langley & Leyson, 2017; Grabher and König, 2020).

An important theme for a future research agenda is the role of governance in the emergence and scaling up of frugal innovations in the era of the 4th IR. To this end, we suggest combining literature on frugal innovation and standards with that on platform governance (e.g. Parker et al., 2016; Van Dijck et al., 2018; Jacobides et al., 2018; Schmeiss et al., 2019). Platform governance deals with rules and standards concerning platform participations, leadership, interaction and value distribution (Parker et al., 2016). Platform governance is arranged by platform firms as well as by platform users and external regulators (Gillespie, 2018). A concrete question for further research is the role of platform firms and of frugal innovators' access to and participation on platforms. A future research agenda could also investigate which actors are contemplating or already implementing what kinds of efforts to strengthen quality control systems on platforms, and to what extent frugal innovators are able and willing to conform to such emerging quality control systems.

A final point relates to temporality. In the introduction we mentioned that we are as yet in the midst of the 4th IR, which makes it difficult to fully grasp its implications. The work by Perez (2015) helps to unpack this issue, at least to some extent. In her neo-Schumpeterian theorization, she uses the distinction between an installation phase and a deployment phase to describe how new technologies spread in society. While the installation phase is about new inventions and the hype they initially create, the deployment phase focuses on the rolling out and further implementation and fine-tuning of currently existing technologies. We hypothesize that platforms and other 4th IR technologies will become increasingly important to frugal innovations in the deployment phase. Therefore, we plan to focus our future research on more mature frugal products and services, and resist the temptation to focus on the latest ‘break-through’ innovations. Perez (2015) also hypothesizes that most of the societal benefits of new digital technologies will be reaped in the deployment phase. We hope our future research will contribute to testing her hypothesis.

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