

## RESEARCH PAPER

## Analysing frugal innovation incubation programmes: a case study from the water sector

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### ABSTRACT

Perceived positive impacts of frugal innovation for sustainable global development have triggered a variety of programmes to foster such innovation. To increase the impact of these programmes, it is important to understand how they function. In this paper, we develop a conceptual framework for the analysis of interventions that foster frugal innovations through incubation. Drawing on relevant theories and concepts in the field of innovation and related literature, the framework is based on two major categories of factors influencing the nature and outcome of frugal innovation incubation. The first category relates to the incubation process, the second to the innovation environment. The proposed framework is applied to the case study of VIA Water, a Dutch programme to foster water innovation in African cities. The framework and the case study presented in this paper demonstrate the complexity of a frugal innovation incubation process and thus the need to take a holistic approach when designing and/or analysing related interventions. We conclude that frugal innovation incubation programmes should consider that the innovation capabilities of potential frugal innovators tend to be weaker in developing than in developed countries. Therefore, incubation programmes should devise strategies that present frugal innovators possessing local knowledge and creative ideas with a realistic chance of competing.

### Introduction: frugal innovation and sustainable global development

Frugal innovation has gained popularity in academic, policy, and business arenas in recent years. The concept refers to a new approach to innovation: one that uses resources economically across the whole innovation value chain and results in products, services, and systems that are environmentally sound, of high quality, and affordable to resource-constrained customers (*Economist*, 2010; Bhatti, 2012; Radjou and Prabhu, 2015). Originally, frugal innovation was associated with emerging markets, characterized by large numbers of consumers who move from the bottom to the middle of the wealth pyramid, thus becoming potential customers (Zeschky *et al.*, 2011). Although the income of these people has increased, they still cannot afford the products and services developed for customers in developed countries. They need products which fit with their aspirations and purchasing power. Emerging markets are also characterized by institutional and infrastructural constraints that make Western innovations unable to reach out to emerging customers (Bhatti, 2013). Therefore, the main idea initially underlying frugal innovation was the development of solutions that fit the peculiar problems of emerging markets (Wooldridge, 2010).

Today it is believed that frugal innovation can help to serve the four billion consumers living at the bottom of the pyramid (BoP) in both emerging and developing countries (Prahalad, 2005;

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Hammond *et al.*, 2007). Demand for frugal innovations is also on the rise in developed countries because of economic crises, which have increased the number of poor customers in these countries, and environmental constraints requiring companies (and societies as a whole) to become frugal (Angot and Plé, 2015). In this context, many people see in frugal innovation the potential to create simultaneously economic, social, and environmental benefits and, therefore, associate it with sustainable global development (Prahalad, 2005; Sharma and Iyer, 2012). There is no unanimity on this question though, as sceptics believe that frugal innovation is likely to increase inequalities among people rather than address the structural drivers of poverty (Schwittay, 2011; Dolan, 2012). Knorrinda *et al.* (2016) suggest adopting an evidence-based approach in order to explore the developmental relevance of frugal innovations. A practical way to do this is perhaps to assess how frugal innovation promotes sustainable development goals (SDGs) (Levänen *et al.*, 2016).

As with any innovation, a variety of actors is involved in the development of frugal innovations (Zeschky *et al.*, 2011; Soni and Krishnan, 2014). In emerging markets, frugal innovations have largely been the preserve of local corporations. However, recognition of market potential and rising competition has encouraged Western corporations to engage in frugal innovation as well. There are also frugal innovators at grassroots level, generally operating in the informal sector (Bhaduri, 2016). Universities are increasingly involved in frugal innovation, either through research (e.g. Centre for Frugal Innovation in Africa, CFIA) or by developing frugal solutions that can be commercialized.

Frugal innovation is increasingly being promoted through specific initiatives across sectors and countries. Granqvist (2016) identified and analysed fifteen public funding schemes that specifically aim to stimulate frugal innovation. A characteristic that is common to many of these frugal innovation support programmes is that they generally tend to function as incubators. Given the increasing interest in incubation-like initiatives, it is important to study and understand how they function and the factors determining their outcomes. In particular, we need to understand whether these initiatives are capable of running according to competitive principles while strengthening local capabilities to innovate. Only then can we influence frugal innovation systematically and effectively.

However, the frugal innovation literature is still characterized by a lack of theoretically sound frameworks to do this kind of analysis. This paper aims to bridge the gap by proposing a conceptual framework for the analysis of interventions that foster frugal innovation through incubation. The framework draws on relevant theories and concepts in the field of innovation and related literature. Two major categories of factors are distinguished (and described) that influence the nature and outcomes of frugal innovation incubation processes. The first relates to the frugal innovation incubation process, the second to the innovation environment. We apply this framework to the case of VIA Water, a programme that supports water innovations in Africa. The case study allowed us to undertake an inductive exploration of how incubation of frugal innovations occurs on the ground and generated insights that validate and/or complement the deductive inputs from theories.

## **Determinants of frugal innovation incubation**

### *Determinants related to the innovation process*

A closer look at interventions to foster frugal innovation reveals that many of them function as innovation incubators. An incubator is often described in the literature as a place where new firms are nurtured to help them survive and grow during their uncertain start-up phase (Fry, 1987; Peters *et al.*, 2004). According to this literature, three main elements serve to capture the essence of an incubation facility: the provision of office space to incubatees (or tenants), provision of professional support, and provision of access to networks. The development of the internet has triggered the emergence of virtual incubators, 'incubators without walls' (Nowak and Grantham, 2000) which allow the provision of services to incubatees located off site. Many of the programmes to foster frugal innovation can be characterized as virtual incubators.

### Three phases of the innovation process

The incubation process is acknowledged as critical for achieving positive outcomes (e.g. Patton *et al.*, 2009). Lalkaka (1996, p.270) argues that an incubator's performance depends on 'the careful planning and implementation of the incubation process'. In his extensive review of incubation process models, Gertner (2013) concludes that incubation involves two major processes: a selection process and a (business) support process. The former uses appropriate criteria and actors to recruit suitable incubatees; the latter involves providing a variety of services to incubatees. The European Union (2010) adds a third phase and describes the innovation incubation process as consisting of three major stages: pre-incubation, incubation, and post-incubation. In studying frugal innovation incubation programmes, we propose to look at the incubation process as involving three major and interdependent phases – the selection phase, the development phase, and the scaling phase. In the selection phase, we include two sub-processes: (1) the process through which strategic innovation areas are defined and creative ideas with potential are mobilized (idea generation) and (2) the process through which these ideas are screened and incubatees selected, based on pre-defined criteria. Incubatee selection has been acknowledged as an important determinant of the incubation outcome (Merrifield, 1987). In the development phase, the analysis focuses on the tangible and intangible resources (or services) needed and received by frugal incubatees from the incubator in order to turn their ideas into frugal products, services and processes. The range and quality of these services decisively drive incubation performance (Smilor and Gill, 1986; Rice, 2002). It is critical to ensure a good fit (or match) between the services offered and the needs of incubatees (Autio and Klofsten, 1998). In the scaling phase, the analysis focuses on the strategies adopted to ensure the spread of frugal innovations.

### Actors and their interactions in the innovation process

Incubation models underscore the role of actors involved in the process and their interactions as important drivers of incubation outcome. A distinction is generally made between internal actors (e.g. the incubatees, the incubator management) and external actors (e.g. consultants, venture capitalists) (Rice, 2002; Bergek and Norrman, 2008). In the context of frugal innovation, resource-constrained customers should be considered a distinct external actor. Frugal innovators ought to interact with and learn from these customers to encourage the production of value-sensitive innovations. Active involvement of customers in innovation processes is referred to in the literature as co-production or co-creation (Brandsen and Pestoff, 2006).

The following four major types of actor interactions can be distinguished and analysed: interactions between (1) incubator management and incubatees, (2) incubatees, incubator management, and external organizations, (3) incubatees and other incubatees, and (4) incubatees and their customers. The intensity and quality of these interactions can influence the incubation outcome to a significant extent. For example, Rice (2002) describes how the time and intensity of the intervention by an incubator's manager, coupled with the breadth of support and readiness of the incubator manager to engage in the process, influence the success of the incubatees. He further argues that the incubation process is affected by the readiness of both the incubatees and of the incubator to engage in the support process. Readiness is therefore another important characteristic to look at when studying frugal innovation incubation initiatives. The readiness of the incubator can be understood by analysing its objectives and resources as these are expected to affect the incubation process (Gertner, 2013). The readiness of incubatees, respectively, can be understood by investigating their ability to acquire and utilize the resources obtained from the incubator. Insights from absorptive capacity and innovation capabilities of the firm literature can be used for this analysis.

### Knowledge co-creation flows during the innovation process

The resources provided to frugal incubatees include knowledge which is continuously co-created and used across all stages of the innovation incubation process. Knowledge flows and learning mechanisms that occur during this process are therefore important influencing factors. These flows can be best analysed using insights from the knowledge management and learning literature

(Senge, 1990; Nonaka and Takeuchi, 1995). In particular, the distinction often made between two categories of knowledge – tacit knowledge (i.e. difficult to formalize and share) and explicit knowledge (i.e. easily expressed, codified, and shared) (Polanyi, 1966) are relevant for the analysis of frugal innovation incubation programmes. Of particular importance here is the knowledge transfer process itself. Research shows that this is a complex and lengthy process as it usually implies integration of new knowledge into the existing knowledge base before it can be used and affect performance (of frugal incubatees) (Nonaka and Takeuchi, 1995; Szulanski, 1996; Mvulirwenande *et al.*, 2013). Thus it is important to analyse whether and what appropriate mechanisms and strategies are devised by the incubator and the incubatees to ensure that knowledge resources are effectively co-created and used to generate value. Rubin *et al.* (2015) proposed the following three types of knowledge as relevant: technological knowledge, market knowledge, and financial knowledge. These knowledge resources are exchanged internally via direct interactions between incubatees and incubator managers (e.g. through face-to-face coaching), networking activities among incubatees, or externally through interactions between incubatees and external actors (Bergek and Norrman, 2008).

#### Absorptive capacity and innovation capability of the firm

The extent to which the knowledge transferred to frugal innovators actually benefits the innovation process is said to depend on their ‘absorptive capacity’. Cohen and Levinthal (1990) defined this term as a firm’s ability to identify, assimilate, and exploit knowledge from the environment. This ability comprises aspects that are distinctly organizational and those pertaining to individual staff members. The literature describes many factors that facilitate or inhibit the absorption of new knowledge by organizations. Internal factors include elements such as prior, related knowledge, level of education, gatekeepers, firm size and age, investment in research and development (R&D), organizational structure and human resource practices, mindset, and power relations. External factors include interaction, cross-boundary expertise and the nature of external knowledge. Daghfous (2004) provides insights into the capacities that incubatees should have in order to absorb knowledge resources obtained during the incubation process.

However useful the concept of absorptive capacity might be, we argue that it is externally oriented (i.e. focused on the ability of firms to absorb external knowledge). To fully analyse the competences that incubatee firms need to innovate, it might be better to analyse their ‘innovation capability’, which is broader than absorptive capacity. There have been many attempts in the literature to identify the core dimensions of the innovation capability of a firm (e.g. Guan and Ma, 2003; Wang and Chen, 2008; Zawislak *et al.*, 2012). The dimensions proposed by these researchers overlap to a great extent, but they all provide insights into the kind of capabilities a firm needs to innovate. For instance, the model of Zawislak *et al.* (2012), which appears more neutral and generic than others, distinguishes among four capabilities: (1) development capability (necessary for imagining and building new value solutions), (2) operations capability (the ability to produce products with quality and reliability at competitive cost), (3) management capability (which allows a firm to integrate all internal capabilities in a coherent way), and (4) transactions capability (required to link the firm to its external environment through purchasing and selling). The model argues that these four capabilities are both individual and organizational. The capabilities are present in all firms, but they vary according to industrial and sector specificities, as well as the firm’s market approach and position in the supply chain.

#### Innovation co-production (co-creation)

The involvement of resource-constrained customers in the innovation process can be a source of competitive advantage for frugal innovators. The concept of co-creation (or co-production) is used in the literature to refer to the learning relationship with customers (Brandesen and Pestoff, 2006). According to Chen *et al.* (2011), there are three major arguments in support of co-production: customers can provide firms with suggestions to improve their innovations; firms can create value by



exchanging resources and co-creating innovations with their partners, including customers; and customers can be a primary source of ideas which innovating firms can apply and turn into products and services. This resonates with the three types of co-creation identified by Voorberg *et al.* (2015) in the public sector innovation context: customers as co-implementers (implementing particular tasks), as co-designers (participating in the design process), and as initiators of innovations. Co-production is associated with many positive outcomes, such as effectiveness and efficiency gains, higher service quality and greater satisfaction of innovation users (Pestoff, 2006), but it entails time and resource investments from all involved actors.

#### Adoption of frugal innovations

Once frugal innovations have been successfully tested, the challenge becomes *how* to ensure they are adopted widely. From the perspective of innovation diffusion, Rogers (2003) argues that the adoption and diffusion curve is *S*-shaped, implying that innovations are hardly adopted instantaneously. He proposes a model with five categories of variables to explain how innovations are diffused: the attributes of innovation, the type of innovation decision involved, the nature of the communication channels used, the nature of the social system in which innovation is diffused, and the role of change agents. Greenhalgh *et al.* (2004) conceptualize innovation spread as a continuum, ranging from pure diffusion (in which the spread is unplanned, informal, and mediated by peers) to active dissemination (where the spread is planned, formal, and often centralized). The market perspective emphasizes the importance of both supply and demand in the diffusion of innovation (Mulgan *et al.*, 2007). Westley and Antadze (2010) acknowledge the importance of market theory in making social innovations work, but they propose coupling it with the institutional change perspective to ensure that such innovations benefit many people. Thus, Westley *et al.* (2014) differentiate between two possible strategies to spread innovations. ‘Scaling out’ strategy emphasizes affecting many people and covering a large geographic area through replication of successful innovation. ‘Scaling up’ strategy focuses on affecting everybody who is in need of the innovation by addressing the broad institutional or systemic roots of a problem (e.g. by changing laws and policies). The importance of these two strategies is nowadays increasingly acknowledged in the scaling up literature (Moore *et al.*, 2015; Davies, 2016; Ubels and Jacobs, 2016).

These views hold for the spread of many frugal innovations as well. Thus, our conceptual framework considers that creating transformative impact from successful frugal innovation pilots depends on a combination of the following two mechanisms: (1) replication of innovation – ensuring adoption of a particular frugal innovation by an increasing number of users, and (2) institutionalization of innovation – ensuring the frugal innovation becomes the norm (e.g. at regional or societal levels), which can be achieved through changes in the form of legislation, policies, development plans, and/or programmes.

#### Innovation sustainability

Frugal innovations that have reached a satisfactory level of performance must be sustainable if they are to be implemented on a large scale and benefit great numbers of users. To be sustained, frugal innovations must meet a number of conditions. First, the innovation must be more cost-effective both financially and environmentally than alternatives in addressing the challenges at hand. This is achieved partly by focusing on core functionalities and by using local resources in the production process. A market-based frugal innovation should be able to provide sufficient returns so that market actors (either innovators themselves or other entrepreneurs) are interested in sustaining and expanding its provision. For this, a sound revenue model is needed. Otherwise, the frugal innovation may be a good candidate for integration into public policy, where it can benefit from existing funding schemes or attract new ones to be sustained. Second, frugal innovations must be socially desirable, technically appropriate and accessible, and financially affordable for the targeted resource-constrained customers.

### *Determinants related to the innovation environment*

The analysis of the innovation environment is informed mostly by the innovation systems literature. The systems approach to innovation became popular in the 1980s as an alternative to the linear model of innovation and through seminal works by such researchers as Lundvall (1992) and Nelson (1993). The systems perspective pulls away from the view that innovation is necessarily and primarily related to research activities. It acknowledges the role of other players in the innovation process. Innovation is seen as involving a variety of actors, networks and institutions; it is a complex and interactive process (Edquist, 1997). Finally, any innovation system is embedded in a much wider system in which socio-economic, political, and cultural conditions determine the direction, scale, and relative success or failure of innovative activities, both at national and organizational levels (Freeman, 2002; Mueller *et al.*, 2013).

#### *Innovation institutional framework*

The present conceptual framework considers a country's institutions an important determinant of frugal innovation. Institutions have formal and informal rules that govern behaviour and structure social interactions (North, 1990). The analysis here focuses on formal institutions as informal rules can be analysed under other key components, such as culture. There are different types of regulations that can help foster innovation activities in a country. Notably, an appropriate intellectual property rights system can be a strong incentive for frugal innovation activities. Suitable regulations on appropriability of innovation outputs and distribution of profits from innovation are equally critical (Teece, 1986), particularly where multinationals increasingly co-create frugal innovations with local enterprises. Innovation policies are another enabler of frugal innovation activities. Frugal innovation can also benefit from institutional deficiencies. For example, when firms operating in weak institutional environments perceive these as an opportunity, they may come up with unconventional, yet effective, ways to deal with them (Radjou *et al.*, 2012). Frugal innovations generally make their way easily in less regulated markets where environmental standards are either absent or not strictly enforced (van de Beers *et al.*, 2014).

#### *Culture and frugal innovation*

Empirical studies indicate that culture influences a country's innovation rate (Shane, 1993; Sun, 2009; Efrat, 2014). National culture may also influence innovation practices and the behaviour of organizations and individuals. Hofstede (1997) argues that in large power distance societies, organizations tend to be characterized by limited informal communication between managers and employees, centralized decision-making structures, and extensive use of formal rules. Such features are expected to constrain knowledge and innovation activities and they are often analysed as part of organizational culture. In the context of frugal innovation, some researchers argue that collectivist societies with a high tolerance for uncertainty (such as India) encourage a frugal mindset. Such societies would also be more comfortable with frugal innovation than other societies (Krishnan, 2010; Soni and Krishnan, 2014). There are many other aspects of regional or national culture that can affect frugal innovation activities. For example, the importance of entrepreneurial culture (e.g. risk-taking attitude, passion for business) as a driver of innovation activity is well known (Spilling, 1996; Shepherd *et al.*, 2010). Places where the entrepreneurial spirit is low are generally associated with low entry of new innovative businesses (Nijkamp, 2003). In liberal systems, open competition is generally accepted as beneficial to the economic activity and firms are expected to work hard to attract customers through innovative products (Schumpeter, 1934). This suggests that regions and countries that are driven by free-market capitalism and a competitive culture are more likely to foster innovation activities.

#### *Historical factors*

Historical factors may also influence innovation activities. One such factor is the institutional legacies of colonialism (Miles, 2014). For instance, colonial legacies of the British and French are

acknowledged to still have a large impact on education, science and research, and innovation activities in Africa (Okey, 2014). Countries or regions with a strong history of entrepreneurial bricolage (or the art of making do with what is at hand) might be expected to lead in frugal innovation. It is no accident that China and India are lead markets for frugal innovation. Not only do the entrepreneurs and companies in these countries have a long history of circumventing their resource constraints and finding ways to solve societal problems, but consumers in these emerging markets are also used to products and services that are practical and ‘good enough’ (as opposed to world-class). Another factor likely to affect frugal innovation is the legacy of traditional Western innovation practices. For instance, with their long history of capital-intensive innovation, many multinational companies find it challenging to innovate (for emerging markets) with limited resources at hand (Govindarajan *et al.*, 2012).

#### Socio-economic and political factors

The literature suggests a number of socio-economic and political conditions that influence the innovation process and its outcomes. The role of financial instruments (e.g. venture capital networks, guarantee schemes, capital investment grants) in fostering innovation and entrepreneurship activities is critical (World Bank, 2010). A country’s business and market environment (rule of law, level of corruption, availability of credit, access to the international market, etc.) can also encourage or constrain local and foreign motivation to innovate (Dutta *et al.*, 2016). The innovation community – the network of actors and how they think and interrelate – is extremely important for promoting innovation activities (Gregersen and Johnson, 1997). For a frugal innovation incubation process, rich networks of actors benefit both the incubator and the incubatees by providing them with opportunities to access the resources they need to perform. On the other hand, human capital stock – the extent of which depends on a country’s education system – is indispensable for innovation to thrive (Barro and Lee, 2000). The availability of talented people is critical to frugal innovation potential (e.g. the ability of multinationals to find competent local partners with whom to co-create frugal products). Innovation is also shaped by the quality of government institutions (Huang and Xu, 1999). For instance, ineffective and corrupt governments constrain the innovative capacity of the periphery regions of the European Union (Rodríguez-Pose and Di Cataldo, 2015).

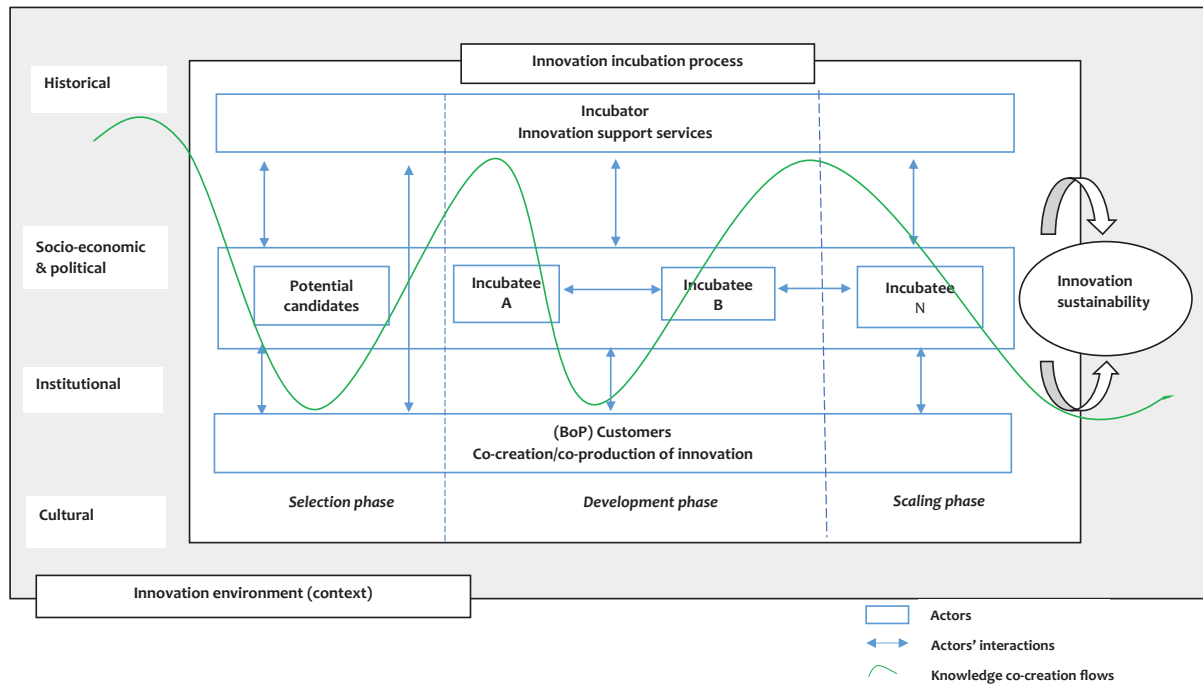
#### *Towards an integrating framework*

Figure 1 schematically presents the factors which determine frugal innovation processes in the context of incubation programmes. It delineates two major categories – factors relating to the innovation incubation process and those pertaining to the external innovation environment. These can be used as a theoretical tool for analysing interventions to foster frugal innovations (see Appendix 1).

### **Case study: the VIA Water programme**

#### *Introduction*

The potential of frugal innovations to tackle water-related challenges in emerging and developing countries is increasingly being acknowledged. Some multinational companies have already started investing in frugal water innovations, with promising results. Swatch and pureit, two water treatment devices developed by Tata Chemicals and Hindustan Unilever respectively, are perhaps the most well-known of these frugal water innovations (Levänen *et al.*, 2016). Nevertheless, compared with other sectors, the water sector is characterized by low innovation dynamism (Wehn and Montalvo, 2018). To accelerate frugal innovation in the water sector, local companies – particularly small and medium enterprises (SMEs) – and grassroots innovators must be encouraged to develop or scale up their frugal ideas. There are already some initiatives in the water sector that aim specifically at fostering frugal innovations, notably through incubation-like programmes. Here we apply the conceptual framework described above to analyse one such intervention, the VIA Water programme.



**Figure 1.** Conceptual framework for analysing interventions that foster frugal innovations through incubation

Financed by the Dutch Ministry of Foreign Affairs, VIA Water supports innovative projects in cities of seven African countries: Benin, Mali, Ghana, Kenya, Mozambique, Rwanda, and South Sudan. In addition to investment capital, innovators receive other support services (e.g. coaching and mentoring) to help them implement their pilots and eventually bring them up to scale.<sup>1</sup>

#### *VIA Water configuration and modus operandi*

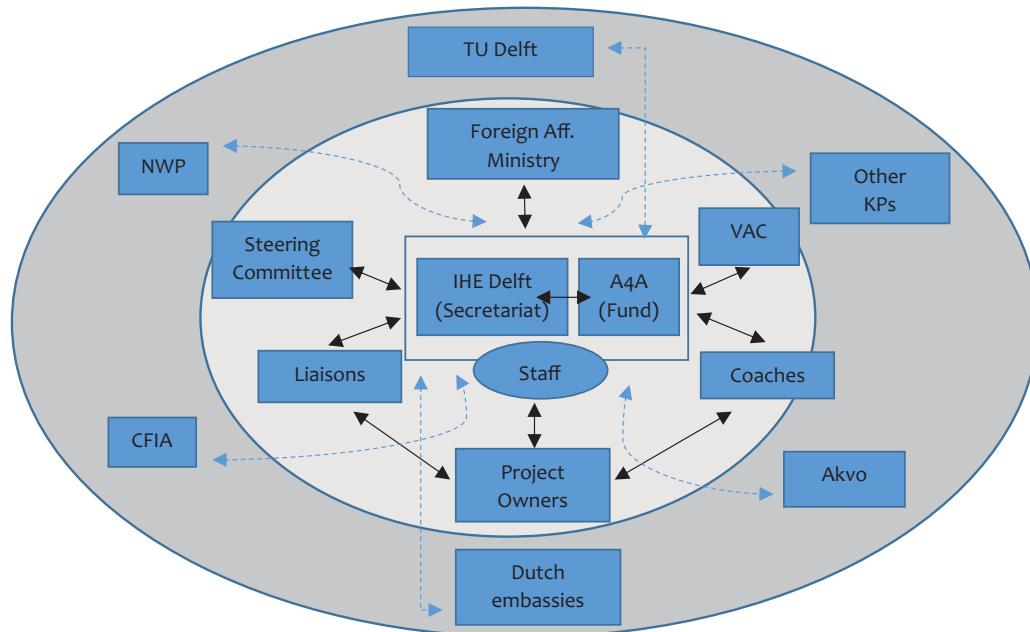
##### Goals and configuration

The mission of VIA Water is to promote innovation in water and sanitation. This is achieved through two concrete objectives: (a) creation of a virtual water learning community in the cities of the seven target countries, and (b) realization of pertinent innovations which have been developed by or in co-creation with African partners (VIA Water, 2015). The programme consists of a network of actors, with complex relationships (see Figure 2). The core of the network comprises actors who are directly involved in the programme, with strong ties, and whose relationships are managed and coordinated through formal contractual arrangements. These network members are IHE Delft Institute for Water Education (which hosts the programme's secretariat, Aqua for All), the fund manager, the Dutch Ministry of Foreign Affairs, VIA Water project owners, the steering committee, the advisory committee (VAC), country liaisons, and the coaches. Finally, the core of the network involves VIA Water full-time staff members (five in total). The programme office team consists of the programme manager, the knowledge management and learning coordinator, and the communication officer. The fund management team consists of two people.

The VIA Water network comprises also peripheral members: those actors who are loosely connected (weak ties) to the core layer. These are notably organizations with an interest in VIA Water's agenda and who can synergize their initiatives with the programme's activities. Examples

<sup>1</sup>The analysis conducted here draws mainly on secondary data, exploratory visits to VIA Water project owners in Ghana and Kenya (conducted in July and September 2017 respectively), and preliminary discussions held with four VIA Water managers in September 2017.





**Figure 2.** VIA Water network

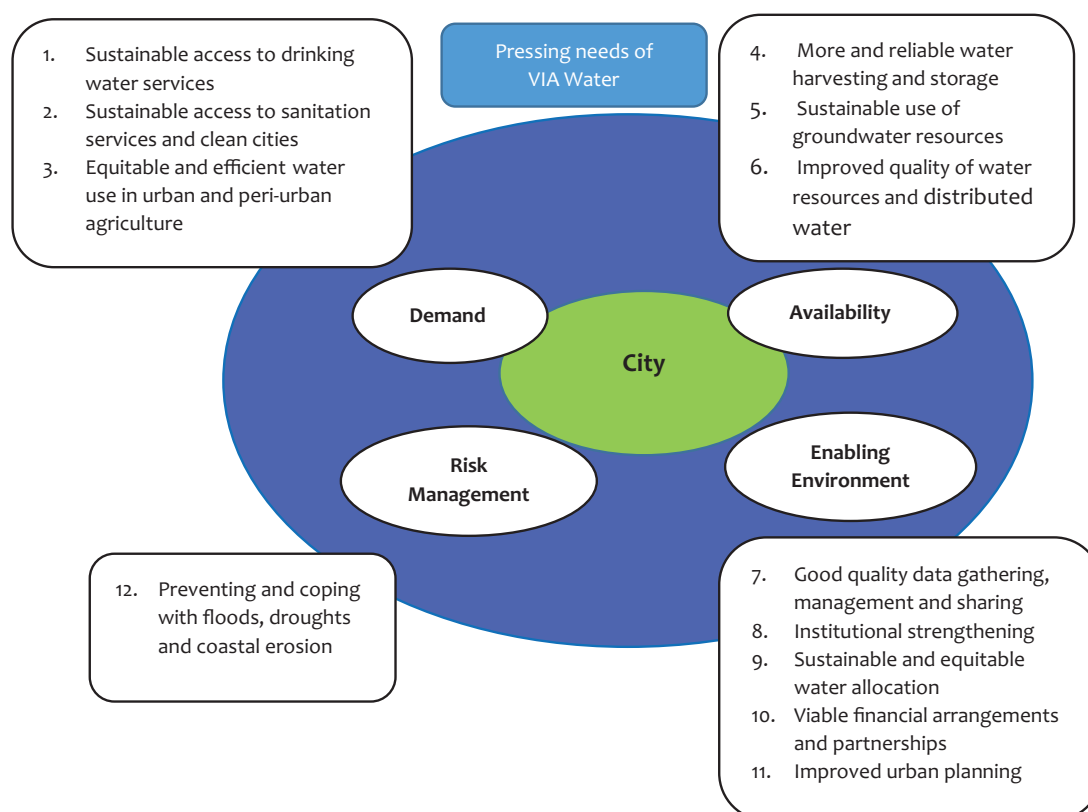
Source: authors

of peripheral members are: the Netherland Water Partnership, the Dutch embassies in target countries, the Centre for Frugal Innovation in Africa, etc. The relationships between these actors and the core layer can be managed through formal or informal contracts depending on the situation. This wide network of relationships provides VIA Water with the resources and information channels it needs to perform as a virtual incubator.

### *The incubation process*

#### Incubatee selection

The innovation incubation process as conceptualized by VIA Water considers the three major phases (selection, support, and upscaling) outlined in the conceptual framework. The programme focuses on twelve strategic innovation areas, the so-called ‘pressing water needs’ (see Figure 3). These were defined through a consultation process with water sector experts and professionals in the Netherlands and in Africa. To stimulate innovative ideas on how to satisfy these needs, VIA Water organizes idea campaigns in target countries, notably through workshops, competitions, and calls for proposals. Interested people can submit a teaser in which they briefly describe their innovative idea. VIA Water managers then fast-screen the teasers and provide first feedback to the applicants. Those with promising ideas are invited to develop and submit full project proposals. Each proposal is jointly studied by the VIA Water secretariat and the fund manager with the support of two external experts to ensure objectivity in the selection process. Unlike many incubators, VIA Water does not rely on a fixed team of experts. Because of the large variety of strategic innovation areas, the programme selects relevant specialists from its wide network on an *ad hoc* basis. The proposals are judged and scored against a number of criteria. These generally relate to the innovation itself (e.g. level of innovativeness, potential for scale-up, sustainability) and the capacity of the innovator (e.g. partnerships, expertise needed to manage the project, readiness to learn). The proposal review is usually an interactive process in which applicants receive feedback in a question and answer format. Once VIA Water is satisfied with the quality of the proposal, the fund manager and programme coordinator jointly take the funding decision. A contract is then signed, which marks the start of the project implementation phase. Since 2015, VIA Water has contracted 63 water innovation projects. Table 1 provides a few examples of water frugal innovation projects supported by the programme.



**Figure 3.** VIA Water strategic innovation areas

Source: VIA Water, 2015

**Table 1.** Examples of frugal water innovations supported by VIA Water

Name of project	Country	Innovation	Innovator(s)
Severe weather warning for Musanze	Rwanda	The project implements a frugal weather system which generates weather predictions and information that is made available to a wide variety of users through phone and web applications. The system also issues alerts on flood and lightning.	TU Delft, TAHMO, Severe Weather Consult
Scaling up household water treatment (try and buy)	Ghana	The project tests a new business model (try and buy) for the large-scale commercialization of household water filters. Families try filters for free and decide whether to buy them after the trial period.	Basic water needs
Mobile desludging device production	Ethiopia	The project develops a frugal desludging device, with local materials and expertise	Waste advisers, Yassin Industries
Closing the water loop for car washing stations in Kumasi	Ghana	The project develops a frugal technology for recycling wastewater from car wash stations	NHance Development Partners

### *Innovation support*

In addition to capital investment, VIA Water provides knowledge and network resources to its incubatees. To start with, relevant knowledge – both tacit and explicit – is exchanged during the Q&A feedback on teasers and full proposals. At this stage, it is common that the programme decides to strengthen the capacity of some applicants (mainly Africans) and to help them bring

their projects to maturity. This is usually done through individual coaching sessions or through so-called ‘innovation challenges’ in which a group of potential applicants are trained on relevant subjects (e.g. proposal writing, business models, marketing, and finances). During project execution, VIA Water continues to provide expert advice to project owners through its managers, local liaisons, and coaches. The online learning community created by VIA Water is another knowledge-sharing channel. VIA Water project owners and managers are the core members of this community, but it is also open to anyone with knowledge and interest in urban water issues in Africa. The community members interact primarily via the internet, but the programme organizes physical encounters from time to time to increase the level of trust among participants. The physical learning opportunities are so far highly appreciated by project owners, but it appears that the virtual approach has not yet generated the expected learning dynamics. VIA Water aims to help its project owners showcase their innovations at strategic events (e.g. international conferences) to attract the attention of potential partners.

#### Innovation upscaling and sustainability

In the VIA Water context, innovation sustainability is assessed on five dimensions: financial, institutional, environmental, technical, and social. During the proposal review and pilot implementation processes, many questions are raised on these dimensions, which help innovators realize (and act upon) potential threats to their projects. The pilot phase of an innovation project lays a strong foundation for larger-scale commercialization. The knowledge and network resources provided to project owners during the incubation process are meant to help them sustain their innovation in the real market. Furthermore, the VIA Water programme encourages project owners to develop and implement their innovations in collaborative networks (or partnerships), which link them to a variety of actors, including policy makers, potential customers, users, and financiers. This approach allows innovators to tap into and leverage the local knowledge and networks which are useful not only for the success of the pilot stage, but also in the subsequent diffusion of fostered innovations.

#### *Other factors affecting VIA Water incubation*

##### Innovation capabilities of applicants

The experience of VIA Water suggests that potential frugal water innovators in Africa face innovation capability challenges. The importance of this problem is best illustrated by the low rate of African applicants who manage to sign a contract with VIA Water. As shown in Table 2, up to July 2017, African lead partners submitted 399 applications (81% of all applications), but only 35 contracts were signed (56% of all contracts). This low rate is associated with a lack of knowledge in project management and other soft skills. This is why the programme committed to strengthen the capacities of African applicants. These findings suggest that programmes like VIA Water should not presume that innovators already have the required human capacity to innovate. It is unrealistic to expect capacity development of incubatees to emerge as a by-product of the incubation process. It should be at the centre of the process and considered at the design phase of the intervention. From a different perspective, one could argue that VIA Water implicitly attempted to circumvent the innovative capability problem by emphasizing innovation partnerships (e.g. between African and foreign organizations) as a selection criterion. So far, it appears that this polycentric innovation approach has allowed VIA Water co-applicants to strengthen each other's capacity to innovate. As demonstrated in Table 2, up to July 2017, the consortia with the highest success rate in terms of obtaining a contract from VIA Water proved to be those involving Dutch/foreign and African partners (VIA Water, 2017).<sup>2</sup>

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<sup>2</sup>Success rate here refers to the contracts/applications ratio.

**Table 2.** Success rates of applicants for VIA Water incubation as of July 2017

Consortia	Number applications	Contracts signed	(%) applications	(%) contracts	Success rate
Dutch/foreign main applicant, rest Southern	46	13	9%	21%	28%
Dutch/foreign main applicant, more Dutch partners, rest Southern	45	15	9%	24%	33%
African/Dutch/foreign main applicant	14	3	3%	5%	21%
African main applicant, rest Dutch/foreign	10	2	2%	3%	20%
African main applicant, more African and Dutch/foreign partners	58	12	12%	19%	21%
African main applicant, no other	189	5	39%	8%	3%
African main applicant, other African partners, no Dutch	120	13	24%	21%	11%
Other	8	0	2%	0%	0%
Total	490	63			13%
Dutch-led consortia	91	28	19%	44%	31%
African-led consortia	399	35	81%	56%	9%

Source: VIA Water (2017)

### Leveraging local knowledge bases and innovation systems

The VIA Water programme has succeeded in reaching out to many ‘high potential’ African innovators. Deliberate efforts were made to mobilize African innovators so that they could first of all pass the competitive selection step and perform well in subsequent stages of the incubation process. Examples of these efforts include VIA Water country visits and learning tours, as well as the accelerator initiative through which individual coaching is offered to improve the proposal writing skills of the applicants. These targeted efforts to foster locally produced frugal innovations and local frugal innovators are in line with one of the programme’s founding principles (‘to stimulate innovations emanating from target countries as much as possible’ (VIA Water, 2015, p.4). VIA Water acts upon this founding principle, appreciating that, although not all African applicants have the skills to compete for incubation acceptance, many are able to propose relevant frugal solutions to local problems.

The VIA Water programme also actively promotes the innovation partnership approach. As a matter of fact, of the 63 VIA Water-supported innovations, 59 innovations are produced through partnerships that bring together foreign and/or African innovating organizations as well as other relevant stakeholders (e.g. ministries, municipalities). Our findings indicate that the partnership approach to innovation has allowed VIA Water-incubated frugal innovators to leverage the local knowledge possessed by domestic partners as well as their local networks. The innovators were able to produce innovations relevant to African cities (e.g. products that consider the low-income levels of water customers). At the same time, these innovation partnerships have enabled frugal water innovators to connect with knowledge and innovation systems beyond the local level. Arguably this could provide frugal innovators with additional opportunities to access external resources (such as new knowledge and funding) and to create value (e.g. by connecting to a global value chain and markets for their products) (see Mvulirwenande and Wehn, forthcoming).

### The role of contextual factors

As in other sectors, there is evidence from the VIA Water programme that country context influences the innovation incubation process. At the moment, this can be illustrated by the performance of applicants from each VIA Water country represented in the application process. As of 2016, Kenya and Ghana had the most applications (82 applications in each case), winning thirteen and eight contracts respectively (i.e., a success rate of 16% and 10%). Applicants from Rwanda and Benin performed very badly. For example, of the 49 applications received from Rwanda, none had reached the contract stage by December 2016; while applicants from Benin had obtained only one contract from 36 applications. Interestingly, as of July 2017, seven applicants from Rwanda had obtained contracts (out of 71 applications, i.e. a 10% success rate), while five applicants from Benin gained contracts (out of 45 applications, i.e. 11% success rate).

The time between submitting a teaser and signing a contract varies from country to country (on average it is seven months). The differences can be attributed to many factors, notably the innovation context in each country, the approach taken by VIA Water managers in specific countries, and the calibre of co-applicants. For example, Kenya is one of the innovation hubs in Africa, with significant talent potential and growing entrepreneurial spirit and activity. Many frugal innovations such as M-PESA (a mobile payment solution) and M-KOPA (a home solar solution) started in Kenya. Thus, it is understandable that Kenyan applicants take less time to reach the contract stage than those from Benin, who have required a lot of support and coaching from VIA Water. The national culture of the target countries might also explain some performance difference. Following Hofstede's (1997) analysis, Kenya appears to be a low power distance country, with a more individualistic culture than, say, Ghana or Mozambique.

### Discussion

The last few years have seen a steady increase in the number of initiatives that support frugal innovation, many of which function as incubators (Granqvist, 2016). This paper has highlighted the urgency for effective promotion of frugal innovation, and the lack of sound frameworks in the frugal innovation literature. Given these challenges, this paper offers two contributions: (1) a conceptual framework that can be used by researchers and practitioners to design and assess interventions that foster frugal innovations through incubation, and (2) insights from the application of the framework of the VIA Water programme, an initiative supported by the Dutch government to foster water-related innovations in cities of seven African countries.

The proposed framework describes two major categories of factors relevant for devising and analysing frugal innovation incubation programmes. The first category relates to the frugal innovation incubation process and includes factors such as how the process is conceived and implemented, the readiness of both the incubator facility and incubated innovators to engage in the process, and the nature and quality of support services for incubatees (Rice, 2002; Hackett and Dilts, 2004). The second category relates to the innovation environment and comprises factors such as the institutional framework, national culture, and the wider socio-economic and political conditions (Edquist, 1997; Mueller *et al.*, 2013). The case-study evidence emphasizes the relevance of these factors and their influence on the nature and outcomes of frugal innovation incubation processes. In line with the conclusion of Lalkaka (1996), the VIA Water *modus operandi* confirms that a carefully designed incubation process – one with clear recognition of the three major phases (selection, support, and upscaling), multiple incubatee selection criteria, and a varied team – allows frugal incubators to recruit suitable candidates and provide them with relevant support services. Although it is still too early to judge the ultimate performance of the VIA Water programme, let alone that of its incubatees, it can be argued that the incubation process as conceptualized by VIA Water has contributed to the positive results achieved so far. The particular configuration of the



VIA Water programme as a network of varied actors – with a mix of strong and weak ties – has contributed to a smooth incubation process by properly equipping it with a variety of resources (finance, knowledge, networks). This finding is consistent with Gertner's (2013, p.205) argument that 'the greater the level of the resources the incubation process provides to achieve its objectives, the more effective the business support process, and the more likely the success of potential new venture creation'. The finding is equally supported by the literature on networks (Gretzinger *et al.*, 2011), which suggests that a balance of strong and weak network ties is necessary to ensure effective flows of resources during the innovation incubation process.

That African applicants to the VIA Water programme have lower success rates, despite the coaching they receive while developing their ideas, suggests that their readiness to be incubated is generally more limited than that of Western applicants. Most of the relevant literature suggests that incubation support services starts right after the selection of incubatees (Merrifield, 1987; Smilor and Gill, 1986; Bergek and Norrman, 2008), but the evidence from VIA Water suggests in fact that effective incubation of frugal innovation and frugal innovators starts during the application stage (see European Union, 2010). Providing support at this stage is particularly important for applicants who may not have the knowledge and skills to compete for incubation acceptance, but yet propose relevant frugal solutions to local problems. The advantage of supporting the application process is further evidenced by the VIA Water strategy to encourage innovation through partnerships, which seems to have worked well. This study is in line with the overall thrust of the open innovation literature (Chesbrough, 2006), according to which strategic alliances allow organizations to innovate efficiently by facilitating access to external resources.

The findings from the case study highlight that the applicants from each VIA Water country represented in the application process perform differently. In keeping with the literature on innovation and entrepreneurship (Drucker, 1985; Dimov, 2010), these performance differences can be attributed partly to the individual characteristics of the applicants, such as prior experience with innovation activities and industrial know-how. The innovation systems literature (Lundvall, 1992; Edquist, 1997) also helps explain the higher success rates of applicants from certain countries. The innovation systems of such countries as Kenya educate potential incubatees, promote entrepreneurial activities, and foster links among actors (see Johnson, 2001; Hekkert *et al.*, 2007).

VIA Water has made considerable effort to reach out to high potential African applicants. Without these targeted efforts, the incubation programme would have benefited the applicants from Western countries far more. These tend to have strong innovation capabilities (e.g. experience and skills to compete for innovation funding), but limited knowledge of local realities. VIA Water promoted the innovation partnership approach as a mechanism to leverage the innovation potential of both domestic and foreign innovators. Thus, the fostered innovators were able to tap into local and international knowledge and networks.

According to the frugal innovation literature (e.g. van de Beers *et al.*, 2014), this kind of strategy enables the adaption of innovations to local circumstances, increasing their relevance for socio-economic transformation and their chance for large-scale uptake. Evidence from recent research (Crespi *et al.*, 2017; Andersen *et al.*, 2018) also supports the central role of local knowledge in producing innovations that contribute to sustainable development. In the context of developing countries, these innovations can be either local adaptations of Western innovations or developed with a completely different innovation approach (e.g. the frugal innovation approach).

Although it is still too early to conclude whether the VIA Water approach to frugal innovation incubation leads to superior performance in terms of long-term success of fostered innovations, the programme appears to have achieved the dual objective of implementing a competitive market-driven frugal incubation process and strengthening local capabilities to innovate. The VIA Water incubation programme has fostered frugal innovation ideas (and frugal innovators) from across the world that address the pressing water challenges facing African cities, and identified frugal water innovators from Africa and strengthened their innovation capacities. We argue that achieving this dual objective is key if frugal innovation incubation is ever to contribute to sustainable global development.

## Conclusions

This paper provides theoretical and empirical insights into frugal innovation research and practice. The conceptual framework and case study demonstrated the complexity of the frugal innovation incubation process and, thus, the need to take a holistic approach to interventions. The application of the framework to the VIA Water case confirms not only the relevance of incubators in fostering innovation, but also how this virtual approach can reach large numbers of potential innovators and entrepreneurs. This is best illustrated by the fact that – in virtual space – the VIA Water programme has been able to identify and incubate 63 water innovation projects across Africa over three years.

The innovation capabilities of potential frugal water innovators from countries with relatively weak innovation systems tend to be weaker than those of their competitors from developed countries with strong innovation systems. This should be taken into account by frugal innovation incubation programmes so that the local knowledge (and creative frugal ideas) of frugal innovators can have a chance in competing for incubation acceptance. A sound capacity development plan is required as part of the incubation process. Given that the national innovation system matters (as confirmed by the case-study results), frugal innovation incubation efforts should be aligned with a country's specific needs. Finally, in an increasingly globalized and competitive world, frugal innovation incubation programmes should promote innovation approaches (e.g. partnerships) that (1) enable frugal innovators to tap into locally and internationally embedded knowledge; and (2) strengthen the capabilities of local frugal innovators and foster a competitive local innovation system. Only then can locally relevant frugal innovations be developed, widely adopted, and contribute to sustainable global development.

## References

- Andersen, A., Marin, A. and Simensen, E. (2018) 'Innovation in natural resource-based industries: a pathway to development?', *Innovation and Development*, 8, 1, pp.1–27.
- Angot, J. and Plé, L. (2015) 'Serving poor people in rich countries: the bottom-of-the-pyramid business model solution', *Journal of Business Strategy*, 36, pp.3–15.
- Autio, E. and Klofsten, M. (1998) 'A comparative study of two European business incubators', *Journal of Small Business Management*, 36, 1, pp.30–43.
- Barro, R. and Lee, J.-W. (2000) *International Data on Educational Attainment Updates and Implications*, NBER Working Paper 7911, National Bureau of Economic Research, Cambridge, MA.
- Bergek, A. and Norrman, C. (2008) 'Incubator best practice: a framework', *Technovation*, 28, pp.20–8.
- Bhaduri, S. (2016) 'Frugal innovation by "the small and the marginal": an alternative discourse on innovation and development', inaugural lecture, Prince Claus Chair, Institute of Social Studies, Erasmus University, Rotterdam, available at [www.eur.nl/en/news/frugal-innovation-small-and-marginal-pcc-inaugural-lecture](http://www.eur.nl/en/news/frugal-innovation-small-and-marginal-pcc-inaugural-lecture) (accessed November 2019).
- Bhatti, Y. (2012) *What is Frugal, What is Innovation? Towards a Theory of Frugal Innovation*, working paper, Said Business School, Oxford University, Oxford.
- Bhatti, Y. and Ventresca, M. (2013) *How can 'Frugal Innovation' be Conceptualized?*, working paper, Said Business School, Oxford University, Oxford.
- Brandsen, T. and Pestoff, V. (2006) 'Co-production, the third sector and the delivery of public services', *Public Management Review*, 8, 4, pp.493–501.
- Chen, J., Tsou, H. and Ching, R. (2011) 'Co-production and its effects on service innovation', *Industrial Marketing Management*, 40, 8, pp.1331–46.

- Chesbrough, H. (2006) *Open Business Models: How to Thrive in the New Innovation Landscape*, Harvard Business School Press, Cambridge, MA.
- Cohen, W. and Levinthal, D. (1990) 'Absorptive capacity: a new perspective on learning and innovation', *Administrative Science Quarterly*, 35, 1, pp.128–52.
- Cooper, A., Gimeno-Gascon, F. and Woo, C. (1994) 'Initial human and financial capital as predictors of new venture performance', *Journal of Business Venturing*, 9, pp.371–95.
- Crespi, G., Katz, J. and Olivari, J (2017) 'Innovation, natural resource-based activities and growth in emerging economies: the formation and role of knowledge-intensive service firms', *Innovation and Development*, 8, 1, pp.79–101.
- Daghfous, A. (2004) 'Absorptive capacity and the implementation of knowledge-intensive best practices', *SAM Advanced Management Journal*, 69, 2, pp.21–7.
- Davies, G. (2016) *Getting to Scale: Lessons in Reaching Scale in Private Sector Development Programs*, Adam Smith International, London.
- Dimov, D. (2010) 'Nascent entrepreneurs and venture emergence: opportunity confidence, human capital and early planning', *Journal of Management Studies*, 47, pp.1123–53.
- Dolan, C. (2012) 'The new face of development: the “bottom of the pyramid” entrepreneurs', *Anthropology Today*, 28, 4, pp.3–7.
- Drucker, P. (1985) *Innovation and Entrepreneurship: Practice and Principles*, Harper & Row, New York.
- Dutta, S., Lanvin, B. and Wunsch-Vincent, S. (eds) (2016) *The Global Innovation Index: Winning with Global Innovation*, Cornell University/INSEAD/WIPO, Fontainebleau, Ithaca, NY, and Geneva.
- Economist* (2010) 'The world turned upside down. A special report on innovation in emerging markets', London.
- Edquist, C. (ed.) (1997) *Systems of Innovation: Technologies, Institutions, and Organizations*, Pinter, London.
- Efrat, K. (2014) 'The direct and indirect impact of culture on innovation', *Technovation*, 34, 1, pp.12–20.
- European Union (2010) *The Smart Guide to Innovation-Based Incubators (IBI)*, European Union, Luxembourg.
- Freeman, C. (2002) 'Continental, national and sub-national innovation systems – complementarity and economic growth', *Research Policy*, 31, pp.191–211.
- Fry, F. (1987) 'The role of incubators in small business planning', *American Journal of Small Business*, 12, 1, pp.51–61.
- Gertner, D. (2013) 'Unpacking incubation: factors affecting incubation processes and their effects on new venture creation', PhD dissertation, Newcastle University Business School, Newcastle upon Tyne.
- Govindarajan, V., Trimble, C. and Nooyi, I. (2012) *Reverse Innovation: Create Far from Home, Win Everywhere*, Harvard Business School Press Cambridge, MA.
- Granqvist, K. (2016) 'Funding frugal innovations: lessons on design and implementation of public funding schemes for frugal innovations', *Technology Monitor*, July–September, pp.31–7, available at [http://techmonitor.net/tm/images/b/b8/16jul\\_sep\\_sf2.pdf](http://techmonitor.net/tm/images/b/b8/16jul_sep_sf2.pdf) (accessed November 2019).

- Greenhalgh T., Robert, G., Macfarlane F., Bate, P. and Kyriakidou, O. (2004) 'Diffusion of innovations in service organizations: systematic review and recommendations', *Milbank Q*, 82, pp.581–629.
- Gregersen, B. and Johnson, B. (1997) 'Learning economies, innovation systems and European integration', *Regional Studies*, 31, pp.479–90.
- Gretzinger, S., Hinz, H. and Matiaske, W. (2011) 'Strong ties, weak ties and the management of innovation: the case of Danish and German SMEs' in Tuunanen, M., Windsperger, J., Cliquet, G. and Hendrikse, G. (eds) *New Developments in the Theory of Networks: Franchising, Alliances and Cooperatives*, Physica-Verlag, Heidelberg, pp.277–98.
- Guan, J. and Ma, N. (2003) 'Innovative capability and export performance of Chinese firms', *Technovation*, 23, 90, pp.737–47.
- Hackett, S. and Dilts, D. (2004) 'A systematic review of business incubation research', *Journal of Technology Transfer*, 29, 1, pp.55–82.
- Hammond, A., Kramer, W., Katz, R., Tran, J. and Walker, C. (2007) *The Next Four Billion*, World Resources Institute and International Finance Corporation, Washington, DC.
- Hekkert, M., Suurs, R., Negro, S., Kuhlmann, S. and Smits, R. (2007) 'Functions of innovation systems: a new approach for analysing technological change', *Technological Forecasting and Social Change*, 74, pp.413–32.
- Hofstede, G. (1997) *Cultures and Organizations: Software of the Mind*, McGraw-Hill, London.
- Huang, H. and Xu, C. (1999) 'Institutions, innovations and growth', *American Economic Review*, 89, pp.438–43.
- Johnson, A. (2001) 'Functions in innovation system approaches' paper delivered at Nelson-Winter Conference, DRUID, Aalborg University, Aalborg.
- Knorringa, P., Peša, I., Leliveldband, A. and van Beers, C. (2016) 'Frugal innovation and development: aides or adversaries?', *European Journal of Development Research*, 28, pp.143–53.
- Krishnan, R. (2010) *From Jugaad to Systematic Innovation*, Utpreraka Foundation, Bangalore.
- Lalkaka, R. (1996) 'Technology business incubators: critical determinants of success', *Annals of the New York Academy Sciences*, 798, pp.270–90.
- Levänen, J., Hossain, M., Lyytinen, T., Hyvärinen, A., Numminen, S. and Halme, M. (2016) 'Implications of frugal innovations on sustainable development: evaluating water and energy innovations', *Sustainability*, 8, 4.
- Lundvall, B.-A. (ed.) (1992) *National Systems of Innovation*, Anthem Press, London.
- Merrifield, D. (1987) 'New business incubators', *Journal of Business Venturing*, 2, pp.277–84.
- Miles, W. (2014) *Scars of Partition: Postcolonial Legacies in French and British Borderlands*, University of Nebraska, Lincoln, NE.
- Moore, M. L., Riddell, D. and Vocisano, D. (2015) 'Scaling out, scaling up, scaling deep: strategies of non-profits in advancing systemic social innovation', *Journal of Corporate Citizenship*, 58, pp.67–84.
- Mueller, V., Rosenbusch, N. and Bausch, A. (2013) 'Success patterns of exploratory and exploitative innovation: a meta-analysis of the influence of institutional factors', *Journal of Management*, 39, 6, pp.1606–36.



- Mulgan, G., Ali, R., Halkett, R. and Sanders, B. (2007) *In and Out of Sync: The Challenge of Growing Social Innovations*, NESTA, London.
- Mvulirwenande, S. and Wehn, U. (forthcoming) 'Promoting smart water systems in developing countries through innovation partnerships: evidence from VIA Water supported projects in Africa' in Han, D., Mounce, S., Scozzari, A., Soldovieri, F. and Solomatine, D. (eds) *ICT for Smart Water Systems: Measurements and Data Science*, Springer Nature, Basel.
- Mvulirwenande, S., Alaerts, G. and Wehn, U. (2013) 'From knowledge and capacity development to performance improvement in water supply: the importance of competence integration and use', *Water Policy*, 15, S2, pp.267–81.
- Nelson, R. (ed.) (1993) *National Innovation Systems*, Oxford University Press, New York.
- Nijkamp, P. (2003) 'Entrepreneurship in a modern network economy', *Regional Studies*, 37, 4, pp.395–405.
- Nonaka, I. and Takeuchi, H. (1995) *The Knowledge-Creating Company*, Oxford University Press, New York.
- North, D. (1990) *Institutions, Institutional Change and Economic Performance*, Cambridge University Press, Cambridge.
- Nowak, M. and Grantham, C. (2000) 'The virtual incubator: managing human capital in the software industry', *Research Policy*, 29, pp.125–34.
- Okey, M. (2014) 'The scientific research wealth of African nations: do colonial origins matter?', *International Journal of Education Economics and Development*, 5, 1, pp.113–25.
- Patton, D., Warren, L. and Bream, D. (2009) 'Elements that underpin high-tech business incubation processes', *Journal of Technology Transfer*, 34, pp.621–36.
- Pestoff, V. (2006) 'Citizens as co-producers of welfare services: preschool services in eight European countries', *Public Management Review*, 8, 4, pp.503–20.
- Peters, L., Rice, M. and Sundararajan, M. (2004) 'The role of incubators in the entrepreneurial process', *Journal of Technology Transfer*, 29, 1, pp.83–91.
- Polanyi, M. (1966) *The Tacit Dimension*, Routledge, London.
- Prahalad, C. (2005) *The Fortune at the Bottom of the Pyramid*, Upper Saddle River, NJ, Prentice Hall.
- Radjou, N. and Prabhu, J. (2015) *Frugal Innovation: How to Do More with Less*, Economist Books, London.
- Radjou, N., Prabhu, J. and Ahuja, S. (2012) *Jugaad Innovation: Think Frugal, be Flexible, Generate Breakthrough Growth*, Jossey-Bass, San Francisco, CA.
- Rice, M. (2002) 'Co-product on of business assistance in business incubators and exploratory study', *Journal of Business Venturing*, 17, pp.163–87.
- Rodriguez-Pose, A. and Di Cataldo, M. (2015) 'Quality of government and innovative performance in the regions of Europe', *Journal of Economic Geography* 15, 4, pp. 673–706.
- Rogers, E. (2003) *Diffusion of Innovations*, Free Press, New York.
- Rubin, T., Aas, T. and Stead, A. (2015) 'Knowledge flow in technological business incubators: evidence from Australia and Israel', *Technovation*, 41/42, pp.11–24.
- Schumpeter, J. (1934) *The Theory of Economic Development*, Harvard University Press, Cambridge, MA.



- Schwittay, A. (2011) 'The marketization of poverty', *Current Anthropology*, 52, 3, pp. 571–82.
- Senge, P. (1990) *The Fifth Discipline: The Art and Practice of the Learning Organization*, Bantam Doubleday Dell, New York.
- Shane, S. (1993) 'Cultural influences on national rates of innovation', *Journal of Business Venturing*, 8, 1, pp.59–73.
- Shane, S. (2000) 'Prior knowledge and the discovery of entrepreneurial opportunities', *Organization Science*, 11, pp.448–69.
- Sharma, A. and Iyer, G. (2012) Resource-constrained product development: implications for green marketing and green supply chains', *Industrial Marketing Management*, 41, pp.599–608.
- Shepherd, D., Patzelt, H. and Haynie, J. (2010) 'Entrepreneurial spirals: deviation amplifying loops of an entrepreneurial mindset and organizational culture', *Entrepreneurship Theory and Practice*, 34, 1, pp.59–82.
- Smilor, R. and Gill, M. (1986) *The New Business Incubator: Linking Talent, Technology, Capital, and Know-How*, Lexington Books, Lexington, MA.
- Soni, P. and Krishnan, R. (2014) 'Frugal innovation: aligning theory, practice, and public policy', *Journal of Indian Business Research*, 6, 1, pp.29–47.
- Spilling, O. (1996) 'The entrepreneurial system: on entrepreneurship in the context of a mega-event', *Journal of Business Research*, 36, pp.91–103.
- Sun, H. (2009) 'A meta-analysis on the influence of national culture on innovation capability', *International Journal of Entrepreneurship and Innovation Management*, 10, 3/4, pp.353–60.
- Szulanski, G. (1996) 'Exploring internal stickiness: impediments to the transfer of best practices within the firm', *Strategic Management Journal*, 17, pp.27–44.
- Teece, D. (1986) 'Profiting from technological innovation: implications for integration, collaboration, licensing and public policy', *Research Policy*, 15, pp.285–305.
- Ubels, J. and Jacobs, F. (2016) 'Scaling: from simple models to rich strategies', working paper, PPP Lab Food and Water, Rotterdam.
- van Beers, C., Knorringa, P. and Leliveld, A. (2014) 'Frugal innovation in Africa: towards a research agenda', paper presented at the 14th EADI conference, Responsible Development in a Polycentric World, Bonn, June.
- VIA Water (2015) *Strategic Policy Framework*, VIA Water, Delft, available at [www.viawater.nl/via-water-strategic-policy-framework](http://www.viawater.nl/via-water-strategic-policy-framework) (accessed November 2019).
- VIA Water (2017) unpublished programme database, VIA Water, Delft.
- Voorberg, W., Bekkers, V. and Tummers, L. (2015) 'A systematic review of co-creation and co-production: embarking on the social innovation journey', *Public Management Review*, 17, 9, pp.1333–57.
- Wang, C-H., Lu, I-Y. and Chen, C-B. (2008) 'Evaluating firm technological innovation capability under uncertainty', *Technovation*, 28, 6, pp.349–63.
- Wehn, U. and Montalvo, C. (2018) 'Exploring the dynamics of water innovation: foundations for water innovation studies', *Journal of Cleaner Production*, 171, S, pp.1–19.
- Westley, F. and Antadze, N. (2010) 'Making a difference: strategies for scaling social innovation for greater impact', *Innovation Journal*, 15, 2, available at <https://pdfs.semanticscholar.org/8ae1/8a04b3f596783ecadf368adb41143cf40942.pdf> (accessed November 2019).

Westley, F., Antadze, N., Riddell, D., Robinson, K. and Geobey, S. (2014) 'Five configurations for scaling up social innovation: case examples of non-profit organizations from Canada', *Journal of Applied Behavioral Science*, 50, 3, pp.234–60.

Wooldridge, A. (2010) 'First break all the rules: the charms of frugal innovation', *Economist*, 17 April, pp.3–5.

World Bank (2010) *Innovation Policy: A Guide for Developing Countries*, World Bank, Washington, DC.

Zawislak, P., Alves, A., Tello-Gamarra, J., Barbieux, D. and Reichert, F. (2012) 'Innovation capability: from technology development to transaction capability', *Journal of Technology Management and Innovation*, 7, 2, pp.14–27.

Zeschky, M., Widenmayer, B. and Gassmann, O. (2011) 'Frugal innovation in emerging markets', *Research Technology Management*, 54, 4, pp.38–45.

## Appendix 1

### Determinants of frugal innovation incubation

Dimensions	Sub-dimensions	Determinants
<b>Innovation environment</b>		
Contextual factors	Cultural	<ul style="list-style-type: none"> <li>• Entrepreneurial culture/spirit</li> <li>• Language</li> <li>• Culture to compete</li> </ul>
	Historical	<ul style="list-style-type: none"> <li>• Colonial legacies (e.g. British and French colonial legacies) on education, research and innovation</li> <li>• Legacies of traditional societies' views on knowledge and innovation issues – e.g. on knowledge and power/age</li> <li>• Legacies of local and or traditional practices of urban water management</li> </ul>
	Institutional	<ul style="list-style-type: none"> <li>• Formal innovation rules and regulations</li> <li>• Innovation policies</li> <li>• Innovation system</li> </ul>
	Socio-economic and political	<ul style="list-style-type: none"> <li>• Regional or national organizations and networks</li> <li>• Supply of talent (human capital stock)</li> <li>• Business and market environment, risky economic environment, availability of credit</li> <li>• Stability of government</li> <li>• Governance (quality of public service, corruption)</li> </ul>
<b>Innovation incubation process</b>		
Selection phase	Idea generation	<ul style="list-style-type: none"> <li>• Definition of innovation strategic areas – the process</li> <li>• Idea campaigns (to foster generation of new and creative ideas)</li> </ul>
	Screening and selection of innovation projects	<ul style="list-style-type: none"> <li>• Selection process</li> <li>• Selection criteria</li> <li>• People involved and their roles</li> <li>• Capacity development support provided during application process</li> </ul>
Development phase	Incubator	<ul style="list-style-type: none"> <li>• Configuration</li> <li>• Objectives and assumptions</li> <li>• Resources (internal and external)</li> </ul>
	Innovation support services to incubatees	<ul style="list-style-type: none"> <li>• Knowledge and capacity development</li> <li>• Networking, mediation</li> <li>• Learning</li> <li>• Funding support</li> </ul>

Dimensions	Sub-dimensions	Determinants
	Interactions among actors	<ul style="list-style-type: none"> <li>• Interactions between incubatees and incubator</li> <li>• Interaction among incubatees themselves</li> <li>• Interaction between incubatees, incubator and other external actors</li> <li>• Interactions between incubatees and their customers (including BoP customers)</li> </ul>
	Incubatees' absorptive and innovation capabilities	<ul style="list-style-type: none"> <li>• Capability to acquire, assimilate, transform and exploit new external knowledge</li> <li>• Innovation development capability (imagine and build new value solutions)</li> <li>• Operations capability (manufacturing capability)</li> <li>• Managerial capability (integrate internal capabilities in a coherent way)</li> <li>• Transactions capability (relate with external stakeholders)</li> </ul>
	Innovator-entrepreneur characteristics	<ul style="list-style-type: none"> <li>• Entrepreneurial experience</li> <li>• Industry experience</li> <li>• Education</li> <li>• Family background</li> </ul>
	BoP customers	<ul style="list-style-type: none"> <li>• Degree of involvement</li> <li>• Stage of involvement</li> <li>• Ability to express needs and provide feedback</li> </ul>
Scaling phase	Replication of innovation (increased number of adopters)	<ul style="list-style-type: none"> <li>• Resources (financial and human)</li> <li>• Innovation champions and/or early adopters</li> <li>• Business models in use</li> <li>• Empirical evidence that innovation works</li> </ul>
	Institutionalization of innovation (through policies legislation, plans)	<ul style="list-style-type: none"> <li>• Alignment on innovation as solution to issues at hand</li> <li>• Innovation champions within the elites</li> <li>• Changes in institutions and policies (in favour of innovation)</li> <li>• Shift in people's attitudes vis-à-vis innovation</li> </ul>
<b>Innovation sustainability</b> Criteria for analysing the sustainability of a frugal innovation: <ol style="list-style-type: none"> <li>1. Desirability and appropriateness – fit with local needs and circumstances (technological sustainability)</li> <li>2. Accessibility and affordability of innovation to resource constrained customers (social sustainability)</li> <li>3. Cost-effectiveness – a market-based innovation must be able to provide sufficient returns so that market actors are interested in expanding the provision of the innovation. Otherwise, the innovation must be a good candidate to be integrated into public policy (financial sustainability)</li> <li>4. Institutional embedding</li> <li>5. Environment-friendly – economic use of resources, minimal negative effects on environment (environmental sustainability)</li> </ol>		