10. Relationship to the agenda of the chosen "top sector"

Code of the chosen agenda part: Cross sectoral: T2: MVI-Entrepreneurship, applied to 'Water' and 'Life Sciences and Health' (LSH).

Motivation:

This proposal responds to example five under T2: MVI-Entrepreneurship: *How can Dutch firms, with local entrepreneurs in developing countries as partners, develop frugal products or systems in order to achieve both profits and developmental outcomes?* The research will be embedded in the Centre for Frugal Innovation in Africa (FIA), one of the strategic alliance research centres between Leiden University, Delft University of Technology and Erasmus University Rotterdam. FIA can (co-)fund additional costs related to organising seminars and dissemination activities.

We propose a new integrative approach that builds on frugal innovations initiatives embedded in FIA as well as frugal innovation projects in private firms to explore entrepreneurial strategies to design, produce and commercialize frugal innovations integrating responsibility (value-sensitivity) elements. We have selected the cases in the top sectors 'Water' and 'Life Sciences and Health' for two reasons. First, in these sectors the Dutch economy excels. Second, these sectors are of key importance for local economic development in Africa. Our cases will provide a qualitative knowledge base from which we will draw conclusions about why, how and when ethical and developmental concerns are effectively integrated into frugal technological design processes and inclusive business models for middle- and base-of-the-pyramid markets.

Word count: 197

11. Description of the proposed research

a. General Scientific quality

Research question

This research aims to investigate new inclusive business models for Dutch companies in order to improve their performance on commercializing frugal innovations in developing countries.

Inclusive business models aim at creating opportunities that lead to profits as well as economic and social development. This requires (1) incorporation of value-sensitive design (VSD) - i.e., context-specific social and ethical values - in the product development cycle (PDC) and (2) entrepreneurial business models taking into account these values through co-designing and co-producing with local entrepreneurs. Frugal innovations refer to engineering by which technological complexity and production costs of goods, services and systems are reduced without sacrificing user value aimed at bringing them within the reach of low and middle-income consumers (see e.g. Prahalad 2012, Van Beers et al. 2012).

We design a new integrative framework including 1) ethical and social elements in the PDC and 2) inclusive business models. The framework starts from theoretical thinking in the technology-, management- and development economics literature and will be further informed through action-learning trajectories in cases of concrete frugal innovations by Dutch companies and universities in Kenya and Uganda.

Scientific importance

Frugal innovation is an emerging field of scientific interest in both product engineering and industrial design, and management and organization theories (Bhatti, 2011; George et.al, 2012; van Beers et.al, 2012). From a scientific point of view little is known about how and under what conditions frugal innovations can be considered successful. It is often seen as a new, disruptive type of innovation that challenges the scientific literature on innovation processes and business models in two ways (Bhatti, 2011; Rao, 2013). First, the engineering process behind frugal innovation is not only about stripping attributes to make products and systems cheaper. In order to make frugal innovations successful they should also be (re-) designed and (re-) engineered taking into account value-sensitivity, i.e., tailor them to the real needs and circumstances of lowand middle-income consumers in developing countries (Prahalad 2012). Second, commercial success of frugal innovations asks for inclusive business models. Traditional product management has a product-centric approach while 'polycentric innovation' is important to address the 'inclusiveness' of (frugal) innovation for entrepreneurs and consumers in low-income countries (George et. al. 2012; Kaplinsky 2011). In other words, commercially successful frugal innovations require new business eco-systems in which innovating firms collaborate with external partners, such as governments, NGOs and local entrepreneurs.

Originality/innovativeness of research

The research is original for two reasons. First, it applies the notions of sociotechnical systems to developing countries, which as far as known to us has hardly been done (in contrast to Innovation Systems, Lundvall *et.al*, 2009). Second, an integrative model is designed along three dimensions: technology (β), entrepreneurship (γ) and values (a). This is innovative because it integrates ethical and developmental values in the early stages of both the PDC and the business model.

Theoretical framework

The integrative approach between PDC and new business models requires the use of insights from four strands of literature. The fundamental foundation of the integrative model is the *socio-technical systems* approach describing design and use of technical innovations from a β - and γ -perspective (Geels, 2004). Our first contribution is the extension of the socio-technical systems approach with *a*-elements by including theoretical notions from the *early engagement literature*, in order to include values in new technologies' development. Our second contribution is the integration of PDC with inclusive business models. This requires the incorporation of elements from literature on *entrepreneurship* (Schumpeter, 1934; Baumol, 1990), on inclusive business models (Lem et.al, 2013) and on local economic development (Helmsing, 2001).

Socio-technical systems

Socio-technical systems, besides a focus on the production of technical innovations, also look at the diffusion and use of innovations (Geels, 2004). Behind production, diffusion and use, elements as technical design, distribution through markets and/or (actor) networks are important as well as user elements such as repair and maintenance facilities and cultural differences. A multi-level perspective is suggested starting from tensions with existing technological regimes leading to opportunity recognition for novelties. These originate not only from technological mismatches but also from tensions due to perceived environmental impacts or health and safety risks, as well as pressures arising from different user preferences due to cultural diversity (Geels, 2004: 914).

Early engagement studies

The field of ethics and technology has shown recently a notable rise in attempts at "early engagement" with science and technology, through interdisciplinary interactions between researchers from the social sciences and humanities with those in science and engineering (cf. Van der Burg and Swierstra 2013; Doorn et al. 2013; Owen et al. 2013; Van den Hoven et al. 2014). Traditional approaches look at the impact of technology after introduction in society. Early engagement interventions focus on the research and innovation process itself and aim at attuning research and innovation processes to societal needs. The role of social science and humanities researchers in early engagement interventions reflects a shift from approving or disapproving certain technological innovations to modulating them such that societal impact and ethical considerations are taken into account in the technological design (Doorn and Nihlen Fahlquist, 2010; Schuurbiers et al. 2013).

The early engagement approach chosen in this project is Value-Sensitive Design, which accounts for human values in a principled and systematic manner (Friedman et al. 2006). This approach is especially appropriate in the context of frugal innovations because it enables to go beyond the mere stripping down of products and to focus on the essential values for frugal innovations. Finding ways to adhere to minimum principles and standards of VSD could prevent a race to the bottom and make frugal innovations more socially responsible and inclusive.

Entrepreneurship

The importance of entrepreneurship as a source of innovations in Western societies was emphasized by Schumpeter (1934). Baumol (2002) argues that firms competing on innovations instead of prices continuously produce innovations in routinized innovation processes. In developing economies local small entrepreneurs often do produce such small innovations, but these are usually not scaled (Grimm *et.al*, 2012).

Local economic development

This dimension refers to the "inclusive" aspect of frugal innovations and business models. Through creation of polycentric innovation networks and new business models, frugal innovations can contribute to economic growth and development prospects of local entrepreneurs in low-income countries by reducing instability and unreliability of existing technological and institutional infrastructures and open up possibilities for local entrepreneurs to become part of global value chains (Altenburg, 2000; Parrilli *et.al*, 2013). This may induce local entrepreneurs to become entrepreneurs in a more Schumpeterian sense: becoming path-breaking by using and applying new combinations of production

factors which could lead to a decisive cost, quality or price advantage, and being able to make profits from 'innovation rents'.

Theoretical approaches input in the integrative model

In Figure 1 the two main elements of the model are presented. First, it shows a frugal innovation development process with a, β , and γ characteristics in a PDC. Second, an inclusive business model including entrepreneurs and local actors.



Figure 1. Integrated frugal innovation development cycle model: Theory.

It also shows how the four theoretical approaches relate to this model. Sociotechnical systems deal with the broad range from opportunity recognition and design to the use of technological innovations. The early engagement literature aims at introducing ethical and social values in the early stages of a frugal innovation PDC, which is important for commercial success of frugal innovations in developing economies with their distinct business environments. Valuesensitive design affects the costs of the PDC. Introducing non-technical elements may well lead to higher communication- and coordination costs hence is likely to decrease the competitive position towards often Chinese and Indian competitors in African markets. This can be controlled through (1) a traditional stage-gate process (Cooper, 2011, Schilling, 2013) and (2) an inclusive business model.

Business models create, deliver and capture value in economic, social and cultural contexts (Osterwalder and Pigneur, 2010). Insights from entrepreneurship and local economic development are relevant to make business models inclusive. Local entrepreneurship is key for two reasons: 1) they are a distribution channel to roll out frugal innovations to local communities, which is particularly relevant for communities in remote areas, and 2) they are important information sources on local user values but also as (co-)innovators to provide new ideas and values into the PDC.

Local economic development comes in as low-income customers demand new products, services and systems that address the specific constraints they have to live with. This is a source of new demand-driven frugal innovations that directly contributes to economic development. An example is M-Pesa that grew out of the constraint of a reliable banking and payment system in Kenya.

Integration of the appropriate inclusive business model in the PDC at an early stage increases the probability of commercial success as potential users will better recognize the usability and values of the innovation.

Research questions

This brings us to the following research questions:

Product development cycle

(1) What are the elements of a 'typical' frugal innovation PDC?

(2) How should such a 'typical' PDC be adapted to include value-sensitive elements? What criteria are relevant to identify the optimal points in the PDC to integrate value-sensitivity in a cost minimizing way?

Inclusive business models

(3) What kind of business models are appropriate to markets in developing economies?

(4) How should these business models be adapted in order to be more inclusive, i.e. generate profit as well as local economic development in a responsible way? How do these relate to increased probability of commercial success?

Synthesis

(5) How and when to integrate value sensitive (ethical and developmental) dimensions into the PDC and business model of frugal innovations?

Approach/methodology

The present literature on frugal innovation consists of many individual case studies, and lacks convincing attempts at systematization. The academic research proposed here starts with five partly related cases. We will collect data in Kenya and Uganda through action learning trajectories to qualitatively validate our integrative framework. Case-based action learning trajectories are an appropriate approach as scientific research on frugal innovation is in its infancy. We aim to arrive at qualitatively convincing typologies and hypotheses, to be subsequently tested in future research.



Figure 2. Integrated frugal innovation development cycle model: Cases

The cases represent various stages in the PDC and the inclusive business model (Figure 2).

Case 1: Philips: A new major effort by Philips to promote innovations in Africa focuses on so-called Community Life Centers (CLCs). These are areas of some 1,000 m² lit with the latest solar powered LED lightning technology. The aim is to enable social and economic development for communities that lack electricity. The idea is that the availability of electricity can 'trigger' a variety of follow up frugal innovations in various domains. We will focus on the impacts of the CLCs themselves as well as on spin-off innovations in water and health, which may provide us with as yet unknown additional cases. CLCs are an interesting platform to experiment with action-research on emerging inclusive frugal innovations that can create more 'light-footed' infrastructures that contribute to social and economic development. CLCs can be positioned in the early stages of a Product (or System) Development Cycle and provide an excellent opportunity to investigate how and when a- and γ -elements will be integrated into the CLC itself and its spin-offs, to optimise the inclusive elements of these initiatives. One such initiative relates to the development of flexible small-scale (drinking) water facilities, in which the Dutch drinking water company OASEN will participate with the research team to develop ideas (see Case 2).

Case 2: OASEN sees opportunities to link their knowledge on (potable) water provisions to the CLCs and use it to come to a sustainable and inclusive water supply at a decentralized level. For OASEN a key attraction to this research setting is that CLCs are not 'imprisoned' by existing heavy infrastructure but one can think afresh about flexible delivery of various qualities of water for various uses and originating from various sources. OASEN starts the PDC with a focus on *a*- and *y*-dimensions around the water demand in CLCs. This can be done together with staff from Hatenboer (Case 3), who specialize in flexible and mobile drinking water facilities. While OASEN specializes in larger and fixed

infrastructures, the expectation is that inclusive water facilities in a CLC would require solutions 'in-between' flexible and fixed water infrastructures. With these two complementary Dutch water companies, and our *a* and γ research capacity, we will contribute to an appropriate PDC and inclusive business model for CLC related water facilities.

Case 3: Hatenboer: Dutch Water Limited (DWL) is a company based in Kenya and part of Hatenboer. Its vision is "Healthy, affordable drink water for all". This is achieved as sustainably as possible and has the extra objective of providing employment for the local population. The technology for the production of drinking water is an adjusted spin-off of their core business technology and well tested. In order to be financially self-sustainable DWL has been experimenting with several business models, which provide very interesting data on their inclusiveness and local development impacts.

Case 4: TAHMO: The Trans-African Hydro-Meteorological Observatory (van de Giesen et.al, 2014) is a joint initiative of TU Delft and Oregon State University (USA), and part of the Centre for Frugal innovation in Africa (FIA). The technical product here is hydro-meteorological measurement stations to be implemented in sub-Saharan Africa. Various Challenges have been organised for African technologists to co-develop the key sensors for these stations (see http://www.youtube.com/watch?v=zJD1VP6F83k). The goal is to develop a dense network of cheap weather stations in order to get much more accurate localised data – crucial for farmers - on weather forecasts. This case provides excellent opportunities for action learning trajectories. They have more or less completed the present PDC, but are now finding that choices for specific business models may well lead to new design implications.

Case 5: Frugal Thermometer: This case is in the early stages of the PDC. It has been developed by FIA through collaboration between Medical Anthropology in Leiden (LUMC), Industrial Design in Delft and local partners in Uganda. The idea is to develop a thermometer without mercury that provides more accurate measurement of body temperature, through a device that is more robust and will be used by local health workers. Improved measurement accuracy will reduce pressure on hospitals

(<u>https://www.youtube.com/watch?v=NieCDfH6Rgk&feature=autoshare</u>). This product is in the design stage but local partners and researchers are already starting to see challenges related to the choice of business model, and its possible implications for future product design choices.

b. Scientific quality within the Responsible Innovation (MVI) frameworks

Interdisciplinary value added

The proposal fits in a trend of research policies aimed at engaging a and γ researchers in early stages of technological research. So far, the focus is mostly on non-commercial Western settings. Our proposal is different as it integrates ethical and developmental values in the design process at an early stage, and also in the business model.

The specific contribution of the moral philosophy researcher is to identify relevant values and indicate operationalization into (frugal) design requirements.

Moreover, at later stages in the PDC intellectual property rights become important.

The γ researchers focus on the integration of innovation management processes and business models design but also on local economic development implications in Kenya.

Design value added

The interaction between technological design and the entrepreneurial business model perspective in the frugal innovation context provides this research a value-sensitive design perspective adaptive to local-context.

c. Research group/embedding of the research

The research will be embedded in FIA, one of the strategic research centres between Leiden University, Delft University of Technology and Erasmus University Rotterdam (<u>http://centre-for-frugal-innovation-in-africa.nl/</u>). The consortium combines the strengths of these three research universities on the nexus technology, entrepreneurship and development. In this study that strength is further reinforced through the practical knowledge by our private partners in the water and health sectors.

The members of the research group are leading in their own relevant field. Van Beers published many papers on determinants of innovation performance of private enterprises in developed countries (van Beers and Zand, 2013). Knorringa is a well-known researcher in the fields of small business, local economic development, and the developmental implications of social standards (Knorringa, 2014). Leliveld specializes in African economic and social development, with a focus on inclusion challenges (Gewald et.al, 2012). Van Beers, Knorringa and Leliveld also collaborated earlier on the theme of frugal innovation (van Beers et.al, 2012). Diehl is an industrial design engineer with a long record track in designing products and services for the Base-of-the-Pyramid and has already been involved in all five cases. Doorn is a pioneer in ethics with regard to the water sector and early engagement in technologies (Doorn et.al, 2013). Van Tulder has a strong record in inclusive business models and innovation management (van Tulder et.al, 2014) and also in the practical field of doing business in Africa (Lem et. al, 2013). Van de Giesen is a water management professor and the successful inventor of the TAHMO weather stations (van de Giesen et.al, 2014). Reis brings in experience from medical anthropology focused on Africa specifically related to the frugal thermometer case (Tol et.al, 2010). Our African partners, Atieno and McCormick, are well known for their work on innovation and entrepreneurship in Africa (Atieno et.al 2010).

We have chosen for one PhD appointment and two PostDocs. The two PostDocs, as more experienced researchers, can rather quickly dig into the respective *a*-and *y*-dimensions of the initial case studies, and synthesize related literatures. This will enable the research team to feed the PhD candidate with appropriate inputs to start working on a more integrated model, starting from her/his beta background. Moreover, the relevant technologists and sustainability staff from our three private parties will work together – in East Africa - with our PostDocs, PhD and the other members of the research team (particularly Diehl and Doorn). This extensive field presence enables us to develop a well-grounded integrated

model connecting the PDC and business model for frugal innovations with attention for value-sensitivity.

Word count: 2986

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