

Local frugal innovations: How do resource-scarce innovations emerge in India?

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Abstract

This thesis investigates the innovation process of frugal innovations at the grassroots level from ideation, to development and finally market entry. Existing literature is focused mostly on frugal innovations in a corporate environment. Nevertheless, also people living at the bottom of the pyramid have potential to innovate useful products. For these innovations the thesis establishes the concept local frugal innovations to emphasize their uniqueness inside the general frugal innovation discourse.

The research is an exploratory case study using three cases from India representing frugal innovations at the grassroots level. Firstly, Mitticool which is a refrigerator made out of clay. Secondly, low-cost sanitary napkins and a machine to produce these napkins locally in villages. Thirdly a milking machine which operates without electricity. The data material is collected mainly from secondary sources using online data and visual data.

The innovation process of frugal innovations at the grassroots level is different in comparison with the traditional innovation process. Local frugal innovators get the idea for the innovation from a problem either he or his family members suffer from it. In the case of local frugal innovations studied in this thesis, the innovator is not highly educated nor a scientist, but rather learning by doing and by using the means at hand. Throughout most of the innovation process the innovator acts alone.

The contribution to literature is the understanding of local frugal innovations and the innovation process. The study shows that the process for local frugal innovations is rather simple, flowing from idea to research and development, finally arriving at a final product. It is only at this point that external support enters the picture.

The innovators have the capacity to conduct necessary research on their own, despite the limited access to financial and other resources. The solution is a holistic answer to the problem, including for instance also the aspect of local rural employment. The innovation can be used widely to people like the innovator himself.

Keywords frugal innovation, local frugal innovation, grassroots innovation, resource-scarcity, India

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Tämä tutkielma tutkii ruohojuuritasolla syntyvien niukkuusinnovaatioiden innovaatioprosessia ideoinnista kehitykseen ja lopulta innovaation markkinoille tuloon. Kirjallisuus on keskittynyt lähinnä niukkuusinnovaatioiden syntyyn yritysmaailmassa. Potentiaalia innovoida hyödyllisiä tuotteita on kuitenkin myös taloudellisen pyramidin alaosassa olevilla ihmisillä. Näille innovaatioille tämä tutkielma luo käsitteen paikallinen niukkuusinnovaatio korostamaan näiden ainutlaatuisuutta niukkuusinnovaatioiden keskustelussa.

Tutkimuksen on eksploratiivinen tapaustutkimus käyttäen kolmea tapausta Intiasta, jotka edustavat niukkuusinnovaatiota ruohonjuuritasolla. Ensimmäinen tapaus on savesta valmistettu Mitticool-jääkaappi. Toinen on edullinen terveysside ja niiden tuottamiseen paikallisesti kylissä tarkoitettu kone. Kolmas tapaus on lypsykone, joka toimii ilman sähköä. Datamateriaali on kerätty pääosin toissijaisista lähteistä käyttämällä online-tietoja ja visuaalista tietoa.

Niukkuusinnovaatioiden innovaatioprosessi on erilainen verrattuna perinteiseen innovaatioprosessiin. Paikalliset niukkuusinnovaattorit saavat idean innovaatioon ongelmasta, josta joko hän tai hänen perheenjäsenensä kärsivät. Tässä tutkielmassa käytetyissä tapauksissa, niukkuusinnovaattori ei ole korkeasti koulutettu eikä tiedemies, vaan oppii tekemällä ja käyttämällä saatavilla olevia keinoja. Läpi lähes koko innovaatioprosessin, innovaattori toimii yksin.

Tutkimus lisää olemassa olevaan kirjallisuuteen käsitteen paikallisista niukkuusinnovaatioista ja näiden innovaatioprosessista. Tutkimus osoittaa, että niukkuusinnovaatioiden prosessi on melko yksinkertainen, ja se virtaa ideasta tutkimukseen ja kehitykseen, tullen lopulta lopputuotteeseen. Vasta tässä vaiheessa ulkopuolinen tuki astuu kuvaan.

Innovaattoreita on kyky tehdä tarvittavaa tutkimusta itsenäisesti, huolimatta rajallisesta pääsystä taloudellisiin ja muihin resursseihin. Innovaatio on kokonaisvaltainen ratkaisu ongelmaan, mukaan lukien esimerkiksi myös paikallisia maaseudun työllisyysnäkökulma. Innovaatiota voivat käyttää laajasti samankaltaiset ihmiset kuin innovaattori itse.

Avainsanat niukkuusinnovaatio, paikallinen niukkuusinnovaatio, ruohojuuritaon innovaatio, resurssiniukkuus, Intia

Table of contents

1 Introduction	1
1.1 Research problem statement and questions	3
1.2 India as a business environment	4
2 Literature review	6
2.1 Frugal innovations	6
2.1.1 Related concepts	9
2.1.2 Sources of innovations	12
2.2 Innovation	14
2.2.1 Linear Model of Innovation by Rogers	15
2.2.2 Linear Model of Innovation by Utterback	17
2.2.3 Linear Model of Innovation for frugal innovations	18
2.3 Bottom of the Pyramid market	19
3 Methodology	22
3.1 Research design	22
3.1.1 Framing cases	23
3.2 Data collection	24
3.2.1 Online sources	25
3.2.2 Video material	26
3.3 Data analysis	27
3.4 Trustworthiness of the study	27
4 Case studies	29
4.1 Mitticool refrigerator by Mansukhbhai Prajapati	29
4.1.1 Research	30
4.1.2 Partners	31
4.1.3 To the market	32
4.1.4 Future ambition	33
4.2 Low cost sanitary napkin by A. Muruganantham	33

4.2.1 Research.....	34
4.2.2 To the market.....	36
4.2.3 Future ambition.....	38
4.3 Milking machine by Raghava Gowda	38
4.3.1 Research.....	39
4.3.2 To the market.....	40
4.3.3 Future ambition.....	42
5 Analysis	44
5.1 Frugal innovations in the local context	44
5.1.1 Reverse and disruptive frugal innovations	45
5.2 The innovation process	46
5.2.1 The innovator and the idea	46
5.2.2 Challenges in the process	47
5.2.3 Partners in the process	49
5.2.4 Market entry	51
5.2.5 Impact and change created	53
6 Discussion.....	56
6.1 Local frugal innovations	56
6.2 The innovation process	58
6.2.1 The idea and innovator	58
6.2.2 Development.....	59
6.2.3 Market entry	59
6.2.4 Linear Model of Innovation for local frugal innovations	60
6.3 Challenges	62
6.4 NIF & GIAN as main partners	63
7 Conclusion	65
7.1 Framework of Local Frugal Innovations	65

7.2 Practical implications.....	67
7.3 Limitations of the study	68
7.4 Suggestions for future research	69
8 References	72

1 Introduction

“I would prize every invention of science made for the benefit of all.”

- Mahatma Gandhi

There are 4 billion people in the world living with less than nine dollars (based on purchasing power parity) a day (World Resources Institute & International Finance Corporation, 2007), and with unserved needs from mobility to health care and education. In everyday language these people are thought of as being poor, those who need help and passive receivers of aid. For decades, activities such as budget support to developing countries, NGO-empowerment and policy programmes, have been the main approach to solve poverty. Yet despite the many efforts, these aid-based solutions have not led to global eradication of poverty, Prahalad (2014) writes. New solutions, which allow poor people to partner with entrepreneurs for win-win situations and to actively be engaged in the development process, are needed. Seeing opportunities instead of challenges can lead to developing profitable products and services for the lowest section in the wealth pyramid called the Bottom of the Pyramid market. (Prahalad, 2014, pp. 27–28).

The interest towards the Bottom of the Pyramid market has also triggered an increasing interest in innovation for the poor and frugal innovations. For instance, M-Pesa mobile banking by Vodafone in East Africa is a well-known example of innovating for the poor. The solution offers access to banking to people, who were previously left out due to the lack of an official address or proof of identification (Bhatti, 2012b). Another one is Arvind Eye Care from India which battles preventable blindness. This is done by offering eye surgeries using advanced technologies at the price level the customer is able to pay (Rao, 2013).

Research in the field of frugal innovation has mainly focused on innovations made by multinational companies and large conglomerates. Case examples have been for instance a small washing machine developed by Haier and an affordable microwave by Galanz (Hang, Chen, & Subramian, 2010), the low-price car Tata Nano (Lim, Han, & Ito, 2013) and the health-care equipment by GE (Immelt, Govindarajan, & Trimble, 2009). Large companies have the access to resources to overcome constraints, internal R&D capabilities and can establish partnerships to gain more know-how, whereas they often lack a thorough understanding of local needs and opportunities (Hang et al., 2010).

Innovators at the grassroots level are faced daily with the challenges of resource-scarcity, and hence understand the local context, the needs of the people with limited incomes and the sources for solutions to overcome the challenges. At the same time, the availability of tangible and intangible resources is limited, which is one major challenge for innovations by the poor (Gupta, 2003).

There is little agreement on the definition for frugal innovations, and there are many related concepts. Essentially, the concept refers to the innovations developed in the emerging country context. The outcome, whether product or service, is consumed by people living on a limited budget. Frugal innovations are often made in a resource-scarce environment and the raw materials used in the final product are simple to assure an affordable product. However, frugal innovations do not compromise on quality, but contrary, the product is of good quality with a low price.

Frugal innovations are different from traditional innovations. For example, whereas in wealthier countries performance and features were the most important qualities of a product, in China price, portability and ease of use were preferred (Immelt et al., 2009). Being early movers and implementing an environment encouraging innovating frugal products, firms find new markets, achieve lower operating costs and are able to create from a niche market an attractive mainstream market (Radjou & Prabhu, 2014, pp. 215–216).

It is not a surprise that it is now that frugal innovations are reaching both the academic and corporate agenda. As a consequence of the economic turmoil, the economic environment in the West has changed, even more consumers consider environmental values and customers increasingly want to buy high quality instead of a lot (Radjou & Prabhu, 2014, pp. 5–8). Research shows that a motivation for the shift to emerging markets, is the competitive pressure from actors in these markets exporting to the developed markets (Immelt et al., 2009; Zeschky, Widenmayer, & Gassmann, 2011).

This thesis will consider three local frugal innovation developed by individuals on the grassroots level in India, who have built a product for the market. The study will investigate what the opportunities and challenges have been in the process and how these have been overcome. The aim is to contribute to the frugal innovation literature by building a theory of the process of local frugal innovations, which is currently missing from the academic literature.

Besides this, the thesis will also add knowledge about local entrepreneurship in a resource-scarce environment, understanding the challenges and opportunities in such an environment and how to then support local entrepreneurship.

The cases considered for this thesis are firstly refrigerators made out of clay by Mansukhbhai Prajapati for the rural villagers who want to store food. Secondly, Mr. A. Muruganantham has developed a low-cost sanitary napkin production machine, for poor women to take better care of menstruation hygiene. Finally, Raghava Gowda has established Ksheera Enterprise to sell the low cost milking machine which he has developed.

It is important to understand frugal innovations also on the grassroots level, as more products and services developed to be affordable, satisfy an actual need and are not harmful for the environment, are needed in countries like India but also globally. Particular interest is for the process of innovation as innovations made in R&D laboratories tend to be too expensive due to the expensive development process. Frugal products create new markets, and can in some cases also disrupt current markets (Bhatti & Ventresca, 2012). Therefore a deeper understanding of frugal innovations for practitioners is very useful. Thirdly, future academic research can benefit from a study made on the innovation process of local frugal products.

Finally, on a practical note, the exchange rate used in the thesis is ₹ 60 equal USD 1. This is based on statistics provided by the World Bank (2015a). The Indian currency has gotten stronger against the dollar over the last year, for simplicity one exchange rate is used to cover the all currency amount over the last years appearing in this research work.

1.1 Research problem statement and questions

The linear innovation model will be used in this thesis to study the innovation process. It has four stages, starting from an idea, which is further developed into a product and finally introduced to its primary market and later also to a possible secondary market. This approach is used to understand the process of the innovation from idea concept to final product, and how the challenges in each stage were overcome. (Godin, 2006).

This thesis will focus on the route the local innovations went from idea to a final product available on the market, with the overall aim being to identify how some innovations become

success stories. The linear innovation process was guiding in formulating the research questions, investigating the journey of local frugal innovations in India from idea to product and commercialisation.

The main research question is *how do Frugal Innovations emerge in India when individuals act as innovators?* The sub-research questions are:

- How has the idea emerged? (Ideation)
- What have been challenges and how have they been overcome? (Development)
- Which individuals or organizations have supported the process? (Development)
- What has been the market entry strategy? (Market Entry)

1.2 India as a business environment

India has often been mentioned together with China as the ideal location for innovating frugal products (Prahalad & Mashelkar, 2010; Radjou, Prabhu, & Ahuja, 2012, pp. 18–19). India is an interesting location in many ways, and not the least for its history. As pointed out by Prahalad and Mashelkar (2010), after independence the country practised socialism, and therefore did not attract many investments from abroad or experience economic growth. The economy opened in the 1980s, and since the 1990s the economy experienced a fast growth pattern (Prahalad & Mashelkar, 2010).

Drawing a picture of India based on statistics from The World Bank (2015b), the Gross National Income was 1 570 USD (current US\$) in 2013, which is a little bit above the South-Asian average. India is categorized as a lower middle income country, yet the GNI is below the average of lower middle income countries. The forecast for the annual growth of the economy is fast and above the South-Asian average. Using the national poverty line, 21.9% of the population in 2012 in India is poor, but the number sees a downwards trend. The major part of the population is between the ages of 15 and 64, whereas one third of the population is below the age of 15 and only 5 % is older than 65. Women account for 48 % of the population. (The World Bank, 2015b).

It is a peculiar place also because of its climate characterized by heat and humidity for most of the year, but also dust can cause challenges for equipment (Ray & Ray, 2010). The average temperatures are above 15 Celsius degrees, the hottest month May with an average of 29 degrees, and the most rain falls during June, July and August (The World Bank, 2015b).

The everyday problems in India are solved with the mind-set of *jugaad*. It is a Hindi word and translates according to Radjou et al. (2012) as “an innovative fix: an improvised solution born from ingenuity and cleverness.” Hence, a *jugaad* entrepreneur does not see constraints as restricting but instead looks for innovative solutions to overcome these constraints (Radjou et al., 2012, p. 4).

In the current Five Year Plan of the Planning Commission (2013), the second decade of the 21st century is announced to be the “Decade of Innovation”. This is to highlight the importance of innovation for sustainable and inclusive growth of the Indian economy also in the future. The Planning Commission (2013) points out, that India has the potential of being a global leader in answering to the challenges of large unmet needs at an affordable rate. As a possible solution inclusive innovation and frugal cost solutions are presented. This is achieved for instance by creating an innovation ecosystem, enhancing support mechanisms and promoting education. (Planning Commission, 2013).

The existing organizations supporting specifically innovators at the grassroots level in India are for example the National Innovation Foundation (NIF) and the Grassroots Innovations Augmentation Network (GIAN). Established in 2000, the aim of NIF is to look for grassroots innovators who have worked on a technological innovation, utilizing traditional knowledge and no help from outsiders (National Innovation Foundation, 2014a). Initiated at a conference in Ahmedabad in 1997, GIAN was established in Gujarat and its main function is to assist innovators to scale-up through for instance market research, assisting in design and funding (Grassroots Innovation Augmentation Network West, 2008a).

2 Literature review

In this chapter frugal innovations are introduced in a wider perspective, also demonstrating the complexities around the notion. Additionally, closely related concepts to frugal innovations are explained to understand the literature on frugal innovations better. This is followed by a brief introduction into the sources of frugal innovations, focusing mainly on corporate and grassroots innovators. Likewise, the linear innovation model and the innovation process of innovations viewed as traditional is explained through the work of two scholars. The chapter is finished with the notion of the Bottom of the Pyramid market.

2.1 Frugal innovations

Frugal innovations are not something of recent times, but quite on the contrary. The historical perspective presented by Bhatti and Ventresca (2013) notes that already the Neanderthals had to cope with scarcity and thus created handy tools. Likewise, during the Second World War most of the labour force was working with activities related to the armed conflict and a major part of the natural resources had to be used for the same purpose. Still the people left behind were in need of for instance clothes, and creative solutions were invented to satisfy needs (Bhatti & Ventresca, 2013). Additionally, *jugaad* is a mentality of resourcefulness, can-do attitude and doing more with less, which is still today practised by Indians in their everyday life looking for solutions to the challenges at hand (Radjou et al., 2012, p. 4).

The current understanding of frugal innovation is scattered. However, Bhatti and Ventresca (2013) have made a first attempt to create a model of frugal innovations (Figure 1). The model highlights three aspects relevant for the understanding of frugal innovation. Firstly, the availability of different type of resources is limited. Activities are also constrained by the low purchasing power of the customers. Secondly, frugal innovations come from emerging markets. There live many people with unsatisfied needs and a limited ability to pay for goods and services. Finally, Bhatti and Ventresca (2013) write, that the lack of institutions creates an environment where the boundaries between formal and informal politics and doing business are blurred. Thus, Bhatti and Ventresca (2013) defined frugal innovations as “the means and the ends to do more with less for more people.”

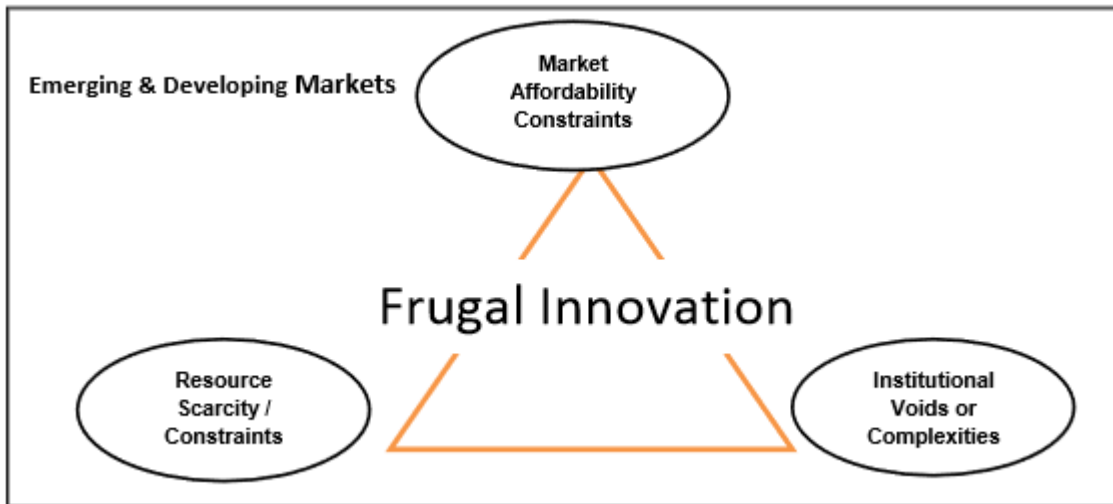


Figure 1 Conceptual model on frugal innovations by Bhatti and Ventresca (2013).

Same aspects but from slightly different angles, are also reflected in other scholars' work. Starting from resource-scarcity, Rao (2013) notes that the design process of frugal innovations starts from scratch and does not follow the traditional process as the aim is to create something new. To keep the costs low, the resource use is limited. The materials can be recycled, using for instance components from existing products. Each function and feature has a purpose of adding value and usability for the user, instead of mainly adding costs and consequently the no-frills version of a product can sometimes be better compared to the traditional product. (Rao, 2013).

Additionally, local firms are faced with the lack of resources, and especially human resources, to develop products satisfying the needs of people. Lim et al. (2013) list a number of strategies to overcome the deficiency problem. These are working in close collaboration throughout the innovation process with partners such as suppliers, having a design to cost approach and using innovation technology to ease the prototyping process. Methods to complement lacking internal human resources are to acquire a foreign firm and having an in-house Resource and Development function to develop the competences of the personnel. (Lim et al., 2013).

The second component of the model by Bhatti and Ventresca (2013) is the market and constraints in affordability. It is a large and diverse market, and the potential customers are demanding yet with a low disposable income. Successful entrepreneurs observe the people to find latent needs to develop products that properly answer to a need. (Radjou et al., 2012, pp. 64–67).

To overcome the issue of low purchasing power, the development and manufacturing are important factors in lowering the total costs and thus the price, increasing the affordability for the consumer. Mettler Toledo (Zeschky et al., 2011) developed and manufactured a basic scale entirely in China, where the local subsidiary received assistance from the global R&D department. Likewise, the firm gained cost advantages as the competent Chinese engineers received a lower compensation. The costs of highly skilled labour, which construct a major part of the total development costs, are lower in China than in the Western world, and therefore frugal innovations are developed in an environment with low labour costs and thus creating a cost advantage (Zeschky, Widenmayer, & Gassmann, 2014).

There is no mutual agreement whether a frugal innovation is also a highly technological innovation. However, some scholars include technology as an integral part of a frugal innovation. For example, Rao (2013) highlights the relationship between cutting edge technology and a low-cost products with the minimal use of resources. These kind of products are the Nokia 1200, the Tata Nano car and the healthcare products by GE, too mention a few (Rao, 2013).

Frugal innovations are developed to satisfy needs of people and offer a clear benefit to the end user. However, the social aspect is not highlighted in the literature. Brem and Ivens (2013) have created a conceptual framework linking frugal and reverse innovations to overall sustainability management. They are arguing, that innovations in the emerging countries can contribute to a company's improvements in sustainability performance. This happens through firstly paying attention to the type and amount of raw materials used, minimizing externalities in the value creation and lastly acting also responsibly with regards to outcomes related to the product manufactured. To make a distinction between economic, environmental and sustainability is avoided in the model to emphasize the link between innovations and sustainability management. (Brem & Ivens, 2013).

In conclusion, frugal innovations are products targeted at the resource-constraint consumer meeting their basic needs, at a low cost but yet delivering value (Zeschky et al., 2011). The products should be of superior value, minimalistic in terms of resources used and answer an urgent need to an extent that they change lives (Radjou et al., 2012, pp. 65–67). The products are designed by using minimal and economized resources, for instance by reusing components and stressing a simple, no frills design (Rao, 2013).

The definition of frugal innovations for this thesis (Figure 2) includes product features, process and benefits of the output. A frugal innovation is a novelty product, thus is new to the market in terms of application, material used or business model, but not necessarily having a new technological feature. Secondly, the product require minimal resources, and the materials used are recycled or easily replaceable. Thirdly, all the features of the product have a value-adding function, instead of a price-increasing or appearance purpose. Most importantly, the product has to have an affordable pricing, either low enough for a single payment or through credit schemes offer the possibility to pay in several instalments. The overall performance in relation to the price have to be in balance and indicate of high quality for the end user. Besides considering the environment and the economic background of the consumer, the product have to increase the quality of life of the customer and have obvious social benefits. Lastly, frugal innovations considered in this thesis are from the emerging markets and made for the emerging market.

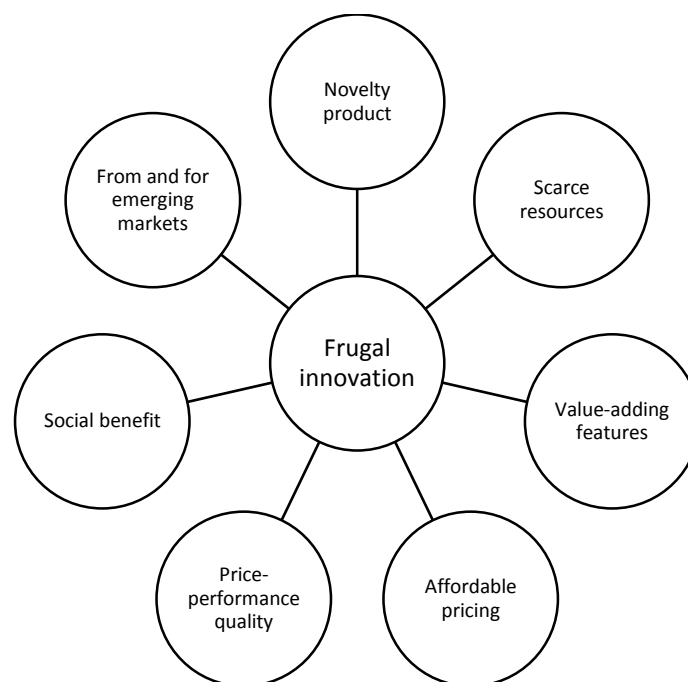


Figure 2 Dimensions of frugal innovation.

2.1.1 Related concepts

The fuzziness of frugal innovations is partly explained by the many theories and notions closely linked to it. In the following section the related concept are introduced.

Traditionally corporations have been seen as the organizations who initiate innovations, but also innovations created at the grassroots level or by users have caught the attention of academia. According to Gupta (2013) products and services innovated at the grassroots combine the skills and knowhow of communities and individuals with modern knowledge, technology and capital.

When users use the functionalities of a product or service differently than intended by the manufacturer or provider and instead add new applications to serve the users' needs better, we talk about user innovations. Van der Boor, Paul, Oliveira, and Veloso (2014) studied for instance M-Pesa, which was launched as a money transfer services but customers were using it to save money, and it was only later that Vodafone launched the savings service, M-Kesho. The users' motivation to innovate comes from the lack of alternatives and a high demand to satisfy a need. Innovation is also enabled by technology, platforms and the low skill level needed. User innovations diffuse faster compared to innovations developed by producers as they seem to address the needs of the people more precisely. (Van der Boor, Paul et al., 2014).

Frugal innovations also have a very particular target market. Prahalad (2014) has introduced the notion of the BOP innovation. He argues in favour of considering the people living at the bottom of the economic pyramid as a market interesting for companies and as a source for innovations. Unlike the traditional view seeing people in the developing world as poor and outside the scope of any economic activity. (Prahalad, 2014, pp. 27–28).

The main argument of Williamson (2010) is, that since customers are becoming more price-sensitive also in the West, companies have to respond to this with a value-for-money revolution and cost innovations. A cost innovation is high technology delivered at a low cost. The market is global, but Williamson (2010) points out that the best capabilities to develop cost innovations are in the emerging country firms. Western firms that want to remain competitive have to give autonomy to subsidiaries in emerging markets, use acquisitions and alliances to gain access to local knowledge, market and supply chains, and combine emerging market assets with existing strengths. (Williamson, 2010).

Examples of cost innovations are listed for instance in the research by Hang et al., (2010). They studied the wind turbine company Suzlon from India and the Chinese microwave manufacturer Galanz, washing-machine producer Haier and electronic motorbike designer Yadea. These

emerging market companies have developed smaller and cheaper products that address a need of people with limited resources from financial to kitchen space. The companies understood the context in which the target customers were living, utilized and further developed local capabilities and saw opportunities instead of the constraints in the environment (Hang et al., 2010).

Disruptive technologies and innovations are not valued by customers today, but will address needs and offer solutions in the future (Christensen, 2003, p. 258). These technologies appear at first glance inferior in comparison with existing products, but they have features early adopters appreciate such as a smaller size, are easy to use and have a lower price (Christensen, 2003, p. xviii). If managers fail to understand the power of disruptive innovations, traditional companies may cease to exist (Christensen, 2003, p. 15). Disruptive technologies were for instance internet enabled learning, online retailing and digital photography which became existing threats for companies operating using established traditional technologies (Christensen, 2003, p. xxix).

There is a link between disruptive innovations and frugal innovations even though not all frugal innovations are disruptive nor are all disruptive innovations necessarily frugal. However, some frugal innovations are so powerful in influencing the daily lives of the poor that they can be considered disruptive in nature. Such an innovation is for example M-Pesa from Eastern Africa. It was originally a development project initiated by the UK development agency DFID (Bhatti & Ventresca, 2012) and has since expanded into a global service revolutionizing the access to banking services, such as credit and savings, and to the formal sector to also include the poor (Bhatti, 2012a).

Innovations, which are created in the developing world and then flow into the developed world, are called reverse innovations (Immelt et al., 2009, Zeschky et al., 2014, Govindarajan & Trimble, 2012, p. 4) as it is opposite of the traditional view of how innovations flow from the developed world to poor countries. Reverse innovations take place in an environment which is different than at home in the West, and therefore managers should unlearn the way of thinking taught in Western business schools and start with curiosity (Govindarajan & Trimble, 2012, p. 14). The innovation is made to address the needs of resource-constraint people (Zeschky et al., 2014) and at a lower cost, with improved quality an accessible even on a constraint budget. (Immelt et al., 2009).

The concept of reverse innovation is closely related to frugal innovations. Zeschky et al. (2014) have drawn a link between the two types of innovations (Figure 3). A reverse product innovation sold in the developed countries, is actually created in a developing country as a frugal innovation (Zeschky et al., 2014). However, not all frugal innovations are suitable for the Western market. Nor are all reverse innovations frugal innovations, as a reverse innovation can also be considered an innovation for a new type of business model or organizational structure (Zeschky et al., 2014).

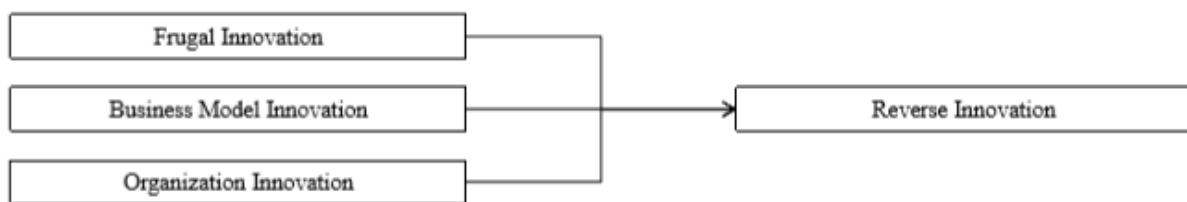


Figure 3 Reverse innovation (Zeschky et al., 2014).

Those frugal innovations, which clearly improve the lives of vulnerable people in society, can in certain cases also qualify as inclusive innovations. It is a term coming from management literature, covering business models, products and services which benefit the poor and disenfranchised people. Essentially it is about a new idea to overcome the barriers to improve the social and economic wellbeing of marginalised people in society. Such an idea can also be a new process, supply chain or institution. Opportunities are found when structural barriers are removed. (George, McGahan, & Prabhu, 2012).

2.1.2 Sources of innovations

There are numerous actors in the field of frugal innovation, which range from political institutions to experts and practitioners from the field. Bhatti and Ventresca (2012) list, educational institutions for teaching students frugality and innovation for the underserved, MNCs for using frugal innovations for differentiation or to gain competitive advantage and entrepreneurs and NGOs for working to find solutions for people neglected by the states' services. In the following the frugal innovation practices of MNCs are and innovations at the grassroots level are introduced.

Western multinational corporations are noticing the potential of companies from emerging markets and modifying their innovation approach accordingly. A classic example is GE, which

increased its investments in India and China and as a result introduced low cost health care equipment (Immelt et al., 2009). Resistance to change may arise from a possible conflict between a high end product line in the developed countries and a frugal products in the emerging markets (Hang et al., 2010). Likewise, Immelt et al. (2009) point out that even those managers with years of experience from the emerging markets, have a preference for glocalization and are still performing “a rich country bias” (Immelt et al., 2009).

To gain success with frugal innovations, a paradigm shift should happen at the management level in Western companies. Zeschky et al. (2011) emphasize that to change the mind-set of managers it is important to embrace the opportunities in frugal innovations rather than fearing them as threats, to understand the characteristics of frugal products and to allow local subsidiaries to have more power and responsibilities. The advantage of Western companies on the emerging market is having a well-known brand and global sales channels (Zeschky et al., 2011).

Later in their research, Zeschky et al. (2014) found that local presence of a Western firm in the emerging market, where the design and development of frugal products takes place, is essential. The role of Western headquarters is to allow the development of capabilities and competencies to innovate locally. Extending the role of a subsidiary in an emerging market to being a value creator allows it to work on product innovations. Besides this, access to global corporate resources, such as technological know-how, marketing and sales channels are also important as innovations created in an emerging market can be introduced in the future as reverse innovations to the developing market. (Zeschky et al., 2014).

The local engineers know the resource-scarce environment very well, and are experts in designing and developing frugal product innovations, Hang et al. (2010) found in his research. They are able to identify the latent demand and needs, and create solutions to solve those problems. Developing local R&D capabilities is crucial for continuous product development. Besides access to R&D competencies, also flexibility and autonomy beyond the traditional relationship between headquarters and subsidiaries is needed. (Hang et al., 2010).

Grassroots innovations are, according to Gupta (2013), created as a response to a failure in the public system to deliver certain services. The people living at the bottom of the economic pyramid might be poor, but they “are not at the bottom of the knowledge, ethical or innovation

pyramid,” Gupta (2013) argues. Emphasizing that instead of exposing policies and programs from top-down, the ownership of development belongs to the people at the grassroots level who therefore have also great potential to act as a source for innovation (Gupta, 2013).

The ideas emerge from a variety of situations, for instance imitating a solution from one field into another (Gupta, 2013). Other practises listed by Gupta (2013), which are used at the grassroots level to develop innovations are through chance, experimenting, trial and error. The resources poor people have at hand are firstly ethical capital, thus knowing what is right and acting accordingly. The social capital is referring to respect for the group one is member of and thirdly natural capital, understanding the limited availability of natural resources. (Gupta, 2013).

Interestingly, Gupta (2013) points out that often the grassroots innovator is not aware that his or her creation is considered an innovation, but instead it is seen only as a simple solution to a problem. The formal sector can thus benefit from the informal sector, and vice versa through, knowledge sharing. Means to encourage local grassroots innovations are wider availability of financial tools to encourage commercialization, rewarding the individuals behind the innovations and building creative partnerships for instance engaging university students and children in innovation processes. (Gupta, 2013).

2.2 Innovation

After introducing frugal innovations and its related concepts, the main focus of the thesis, it is time to look how innovations have been defined traditionally. To better understand the process, similarities and differences between corporate innovator and frugal innovators, the linear model of innovations is introduced. Even though the linear model is not developed to explain well the uniqueness of the frugal innovation process, this model was selected in the absence of better models.

Utterback (1974) says an innovation in the traditional sense is “technology actually being used or applied for the first time.” Likewise, Rogers (2003) defines innovations as being something new, but emphasizes that the degree of newness is upon the customer to define. “If an idea seems new to the individual, it is an innovation,” he writes. He also lists five characteristics of successful innovations. These are relative advantage, referring to the perceived benefits and advantages attached to the innovation. Secondly, compatibility in terms of fitting into the

current value system. An innovation also has a certain degree of complexity and an aspect of triability to reduce the uncertainties of the customer. Finally, observability of usage of an innovation by others helps the broader adaptation of an innovation. (Rogers, 2003).

Basic research → Applied research → Development → (Production and) Diffusion
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Figure 4 The linear model of innovation. (Godin, 2006).

The linear model of innovation (Figure 4) has evolved in three phases since 1945, writes (Godin, 2006). First, basic research was accompanied by applied research. These are separate yet collaborating and having a flow of knowledge from basic to applied research (Godin, 2006).

In the second phase the industrialists added the notion of development to the innovation process. The understanding was that engineers are in charge of both the research and the development process within the same department. The activities included in this phase were for instance designing and engineering, piloting and testing, and improving and trouble shooting. During the 1960s, production and diffusion of an innovation were added to the model by economists. Sociological literature and product-life cycle literature influenced the understanding of diffusion and commercializing innovations. (Godin, 2006).

Godin (2006) also argues, that the model is simplified and rhetorical and explains that it should be used as an analytical framework for policy making, allocation of budgets or statistical purposes.

Many scholars from different disciplines have added their contribution to the development of the linear innovation model and the diffusion of innovations. In the following the views by two different researchers, Rogers (2003) and Utterback (1974), are introduced to get a better understanding of the linear innovation model. The chapter is finished with an overview of the suitability of the linear model of innovation for the grassroots innovation context.

2.2.1 Linear Model of Innovation by Rogers

Since the 1960s, Rogers (2003) has been studying innovations, and in his view the development process of an innovation goes through six steps (Figure 5), each of which consists of decisions, activities and impacts. He also noticed that the steps do not always occur in this order nor do all the steps occur in each innovation process (Rogers, 2003).

Needs/problems → Research (basic and applied) → Development → Commercialization → Diffusion and Adoption → Consequences
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Figure 5 The six stages in the Innovation-Decision Process (Rogers, 2003, p. 138).

The process described by (Rogers, 2003) starts with recognizing a problem. This happens by scientists identifying a future problem and researching possible solutions. Needs may also arise from a social problem which reaches the public agenda. In that case the problem is answered to also with public policies, and the problem is defined besides scientific research also through political power. (Rogers, 2003, pp. 137–139).

In the second stage research into the topic takes place. It is both basic research, which has no intention to provide everyday implications, and applied research, which aims specifically at solving a practical problem. Successful research leads eventually to a registered patent. An innovation may, however, also occur unintentionally as serendipity while doing research for something else. (Rogers, 2003, p. 140).

The processing of an idea happens people when talk and share information about their needs and wants (Rogers, 2003, p. 144). Ideas are also further developed through a lead user who has a new need before the average user faces the same need. He or she creates a prototype and thereafter tries to take over the role of an innovator within a firm (Rogers, 2003, p. 142).

The third stage is development, during which the aim is to develop the idea into a first prototype which would answer the needs of the customer, utilizing the findings found through research in the previous phase. During this stage a lot of information is required from the users for whom the innovation is created. Here uncertainty is created through lacking or misleading information. (Rogers, 2003, pp. 146–147).

During the development stage the innovators also need to take into account the acceptability of the innovation. For instance technologies are always reflecting the norms and values in society (Rogers, 2003, p. 148). Rogers (2003) also introduces the notion of skunkworks. Highly skilled and motivated workers are selected to work together on an innovation project with all

resources available and bypass the bureaucratic hurdles created by organizational structures (Rogers, 2003, p. 149).

This is followed by the commercialization phase, during which the idea will be transformed into a product or service and made available on the market. This stage includes everything from production to packaging and from marketing to distribution. It is implemented mostly by private companies. Commercialisation also occurs when the innovator is a practitioner or a lead user. (Rogers, 2003, p. 152).

Finally comes the diffusion and adoption phase. Sometimes there is pressure to introduce the product to the market as soon as possible, whereas other times the gatekeeping, thus controlling the entrance of innovations to the market, might be necessary. Reputation and keeping a reliable image might be reasons to slow down the diffusion process. (Rogers, 2003, pp. 155–156).

The last stage of the model by Rogers (2003), consequences, refers to the change triggered by the innovation or the refusal of the innovation, in an individual's life or in the system (Rogers, 2003, p. 157).

2.2.2 Linear Model of Innovation by Utterback

Utterback (1974) argues that the innovation process has only three phases. It starts with the generation of an idea, followed by a problem-solving phase and finally the diffusion of the idea (Figure 6). Most of the successful new ideas come from outside a firm answering to demands and needs identified in the market, or through advancements in science and technology. Outside sources of ideas for new innovations are for example consultants. Additionally, the network, the educational background and personal experiences help the innovator to find ideas, and innovators are in general highly educated. (Utterback, 1974).

Generation of an idea → Problem-solving/development → Implementation and diffusion
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Figure 6 Innovation process by Utterback (1974)

Developing an innovation can either start by recognizing a need which then leads to identifying the appropriate technology, Utterback (1974) has found. Another option is to adapt

technological improvement and find a use for it. The role of basic research is primarily to add to the understanding on a certain issue and to educate, rather than being used directly as a source of innovation. (Utterback, 1974).

During the problems-solving stage, the design of the final innovation is specified. An important tool in problem-solving is communication, and whereas in the idea generation stage communication mainly comes from outside, in the second step a mayor part is generated by the innovator. (Utterback, 1974).

In the last phase of the model by Utterback (1974) the innovation enters the market. It first has to be manufactured and the market needs to be prepared for acceptance of the product. Personal networks and informal communication are again important in the diffusion stage. The process from information gathering until the final innovation takes on average eight years, with some variety depending on the industry and size of the firm (Utterback, 1974).

Utterback (1974) also adds the notion of spin-off companies which are heavily based on technology, grow fast and enter new markets. The companies are established by individuals who left the parent company, and became very innovative. The spin-off companies have often used as a market entry strategy the public sector, such as the defence and space industries, as their first customer. As a consequence of fast growth, these companies turn into a significant employer. (Utterback, 1974).

Challenges in the process listed by Utterback (1974) are created by issues with communication and ability to act within the firm. Additionally, availability of resources and the organizational structure with a variety of different strategies create also a challenge. Firms face uncertainty in the innovation process, such as the reliability of the information and stability of external factors of the firm. Likewise, a deep understanding of the environment in which the firm is operating and the integration of the different functions is important to overcome the uncertainties. (Utterback, 1974).

2.2.3 Linear Model of Innovation for frugal innovations

As mentioned above, the linear innovation model was chosen for the reason that better models to explain innovations emerging from the grassroots level do not exist in academic research

yet. The assumption in the thesis is that this model does not fit for frugal innovations firstly due to the unique situational context these innovations emerge from. The innovations arise from emerging countries and environments which are characterized with resource-scarcity in terms of both financial and human resources.

Secondly, the customer base targeted with frugal innovations are also defining the process. As the customers alike have a constrained budget, the innovation process has to be simple to keep the costs low and the final product affordable for its intended users. Additionally, the features and design of the innovation are primarily used to improve the performance and the usability of the product before esthetical aspects.

Thirdly, frugal innovations are regarded as novelty products with a high degree of newness. This arises partly from the reason of applying a unique development process to the innovation.

2.3 Bottom of the Pyramid market

Frugal innovations come from a resource-scarce environment, with limitations in resources, institutional capabilities and the target customers' ability to pay (Bhatti, 2012b; Prahalad & Mashelkar, 2010). The willingness to act and nurture the opportunities in resource-scarce environments puts pressure on the cost structure, performance indicators and capital efficiency of companies doing business the traditional way (Prahalad & Hart, 2002).

The Bottom of the Pyramid market is commonly understood as the market of 4 billion people globally in the poor and lower middle class earning less than 3000 USD (based on purchasing power parity) annually, which amounts to 9 USD daily. This number is including the 1 billion people who live with less than one USD a day. These people are in the development discourse often referred to as being extremely poor. It is worth pointing out, that in India 95 % of the total population is considered belonging to the BOP market, and one third of the total population lives with less than 3 USD per day (Figure 7). (World Resources institute & International Finance Corporation, 2007).

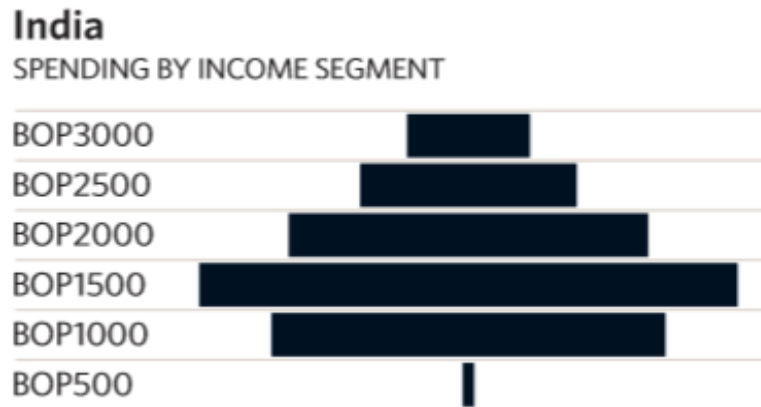


Figure 7 Market size based on expenditure equal to income. (World Resources institute & International Finance Corporation, 2007).

Prahalad (2014) describes the BOP market both as rural and urban. People are living in rural villages or in the slums of cities, rarely have legitimate ownership of their assets such as land or house, mostly work in the informal sector receiving salary on a daily basis and have low or no education. The BOP consumer buys affordable products which are accessible with little effort even in remote areas and are available when needed. Mobile phones and credit schemes have made consuming easier, and in general poor people are accepting new technologies as there is no unlearning required regarding the new usage patterns. Albeit, the low purchasing power, poor people live with a poverty penalty, meaning that basic services are more expensive for those with already limited financial resources. (Prahalad, 2014, pp. 34–46).

Despite the many challenges, the BOP markets offer also many possibilities. The lack of infrastructure and structures gives an opportunity to leapfrog straight to better solutions without repeating mistakes made in the west. It is also an excellent environment to test new technological solutions and a source for new innovations, both of which can later be offered also on a global scale. The amount of people living at the BOP is one third of the world population, and therefore profits come from low margins but efficient use of capital and volume. (Prahalad & Hart, 2002).

According to Govindarajan & Trimble, (2012) there are five gaps which highlight the key differences between emerging markets and developed markets, and are at the same time also opportunities for innovations. Firstly, customers want the maximum level of performance at a price level as low as possible. Physical, social and institutional infrastructure is insufficient in the developing countries, yet it can also be seen as a source of innovation and it is a location to

implement first-class technology leapfrogging traditional infrastructure. It is also likely that sustainable and green solutions come forth in developing countries where sustainability problems are severe. The fourth gap, the regulatory framework, is often seen as a constraint but can also be an opportunity when needless regulations and bureaucracy are not hindering innovations. Finally, the tastes, habits and rituals differ among people and this diversity is also a source for innovations. (Govindarajan & Trimble, 2012, pp. 15–18).

3 Methodology

In this thesis a multiple case study approach will be applied. Case studies have a long tradition of being used in sociology, anthropology and business, to mention a few, to understand social phenomena (Yin, 2003, p. 1), and it is often utilized to illustrate phenomena in case it is not yet well understood in literature (Gummesson, 2008). As seen before, frugal innovations and its many related concepts prove that it is as a concept “ambiguous, fuzzy and even chaotic” (Gummesson, 2008). For this reason, the case study design is the research design to gain an understanding of how Frugal Innovations emerge in India when individuals instead of multinationals act as innovators. When doing research, thorough attention will be paid to thick descriptions because these add to the conceptual understanding of the case (Dawson, 2010).

The ontological starting point of this study is objectivist. It assumes, that frugal innovations exist before a theoretical framework can explain the processes and features of such innovations. In terms of epistemology, the starting point is as well objectivist. Knowledge comes from an external and theory neutral world. In this study the data used represent reality and are the base from which theory will be developed. The philosophical position is positivist. (Eriksson & Kovalainen, 2008, pp. 13–15).

3.1 Research design

Multiple case study was also chosen since according to Chmiliar (2010) multiple case studies are used to study processes, which is the main interest in this thesis. Comparison with other cases for similarities, situational conditions and the like, make the results more powerful and more generalizable (Chmiliar, 2010).

The study is using an exploratory research design to discover the local frugal innovation processes of individual innovators in India. Streb (2010) explains that exploratory research is being used in preliminary research and therefore beneficial when studying emerging topics such as for instance frugal innovations. As a method exploratory research offers flexibility when it comes to research design and data collection method, yet proving the reliability and validity of the research. Similarly, exploratory research approach is often utilized when access to data is limited, which is also the case in this study due to the distance to the researched innovations. (Streb, 2010).

An extensive case study is chosen over an intensive case study, in which one case is assessed and aimed at understanding whereas the extensive case study aims proposing new theory. The approach used focuses on one issue, thus frugal innovations, and studies it through several cases. Through similar data found, each case will add something new to the understanding of frugal innovations. The aim of this study is thus to understand how the frugal innovation process flows in the context of an Indian individual innovator, and to propose a theory on that understanding. (Eriksson & Kovalainen, 2008, pp. 119–125).

3.1.1 Framing cases

As Eisenhardt (1989) explains, that the selection of cases for this study was not random, but instead “replicate previous cases or extend emergent theory, or they may be chosen to fill theoretical categories and provide examples of polar types.” In theoretical sampling, the cases are selected with theory development in mind and the chosen cases represent extreme types to best represent the phenomena studied (Eisenhardt, 1989). Therefore, for the purpose of this thesis, three innovations were chosen firstly since they are extreme cases in the entire spectrum of frugal innovations and thus the selected cases come from an exceptionally resource-scarce context. This distinction rules out frugal innovations developed in a corporate environment in an emerging country, which is getting attention from academic research already, but instead focuses only on innovations from the grassroots.

Further selection criteria were that the innovation process of these three are completed. The products are successfully sold on the market whereas many other innovations are never commercialized and operate only on a small scale. Thirdly, the background of the innovators is similar as they are all from India and share the characteristics of being very innovative and persistent overcoming the challenges of innovating in a resource-scarce environment. Finally, an additional, pragmatic concern for the selection was made based on availability of data, as it was crucial use data available which the researcher could access without traveling to India.

According to Stake (2006, p. 1), in multiple case studies each case should be considered as a single entity representing the phenomenon but the cases need to have something in common. In this thesis, the cases studied have a similar beginning to the process and, albeit the innovative product outcome itself is different, all three innovations are products sold with a noteworthy presence on the market whether in India and in other countries. The three innovations are

generated by individuals from India, the innovations are made for the Bottom of the Pyramid market, and fulfil the characteristics of a frugal innovation.

3.2 Data collection

As Eisenhardt (1989) recommends, a combination of sources was used in this study to collect data on the cases, to provide a good overview of the context and to be descriptive. Multiple sources were also important as it allowed triangulation of data to understand the phenomenon studied holistically and it increased the trustworthiness of the entire study as each source added something new to the case study (Eisenhardt, 1989).

Most sources applied in this thesis are categorized as secondary sources, representing knowledge gathered and compiled by a third party, which is neither the researcher nor the individual studied (Eriksson & Kovalainen, 2008, pp. 77–78). These are for instance news articles, a documentary made about one of the innovations and talks published online. A limited amount of primary data is gathered by the researcher straight from the cases (Eriksson & Kovalainen, 2008, p. 77). This is for instance information from the websites.

For the purpose of this thesis secondary data was chosen because it is readily available online, with the minimum costs and efforts but yet with high benefits. The researcher is located in Finland whereas the innovations and persons who developed those innovations are located in India. That created the initial scenario to turn away from primary data, such as interviews and observations, to secondary data, which is grandly available from a number of different sources and besides textual data also visual data can be utilized.

As most of the data comes from secondary sources, the method used for gathering information is through online search engines. The strengths and weaknesses of each source were analysed thoroughly before adding material to the data collection (Eriksson & Kovalainen, 2008, p. 126). All the sources used to construct the case study were all telling the same story, yet each adding small pieces of information and missing details.

Using secondary data as opposed to direct contact with the persons behind the innovations may raise questions of data quality. Rasmussen (2008) lists three approaches to data quality: the intuitive, prescriptive and empirical approach to data quality. The intuitive approach has not

theoretical not methodological background and is thus not used in this thesis. Instead, ensuring data quality through the prescriptive approach was a balance between costs and expected benefits. Gaining access to certain data sources required more effort than access to others, but never compromising the benefits gained from the additional data. The empirical approach to data quality refers to the role the researcher as the user of data had in ensuring data quality. (Rasmussen, 2008). Below the data sources are briefly explained.

3.2.1 Online sources

Rasmussen (2008) argues, that Internet has become a new way to access data. It has eased the data collection as much of the data is already available online at little extra cost (Rasmussen, 2008). For the purpose of this research a number of different online sources have been collected, which was the requirement set by triangulation to build a holistic picture of the innovation process. Firstly, the websites of the three innovations was studied. This data can be considered coming directly from the innovators themselves and therefore primary data.

Secondly, all three innovations have been widely covered in the Indian media, and so Hindustan Times and Economic Times have written stories of Mitticool. Articles about the milking machine can be found in India Today and Outlook India. Similarly, the low cost sanitary napkin machine has also drawn the attention of international media, such as BBC, in addition to local media such as MinnPost.

NIF has awarded Mr. Gowda in 2005, and Mr. Mansukhbhai and Mr. Muruganantham in 2009 for their innovations, and the award book from those years have extensive stories of the innovations. Additionally, the NIF has made profiles of the innovations and the person behind them, but also for instance the price of the innovation and information on the patent related to the innovation.

In addition to the above mentioned sources, which each innovation had in common, there are also a number of organizations and networks that have published case studies and reports on one of the innovations. The Grassroots Innovation Augmentation Network and the Permaculture Research Institute conducted a small study about Mitticool. The Singapore Management University has written a case study about the development process of the sanitary napkin machine. The Society for Research and Initiatives for Sustainable Technologies and

Institutions (SRISTI) covered the milking machine in its final report for the Grassroots Innovations for Inclusive Development (GRIID) project.

3.2.2 Video material

As MacQuarrie (2010) argues, using visual data in this research has the function of adding significant knowledge of the context and the personalities of the innovators, and for that reason videos were also used as data material in this thesis. While studying video material, the content and the context in which the visual material is seen and understood, were taken into account (Pink, 2006). Analysing visual data is linked to some subjectivity as the researcher's assumptions are present (Pink, 2006) but in this thesis it was also seen as objectively portraying reality while taking into account its limited ability to represent the truth (MacQuarrie, 2010).

The visual data can be either created for the research or something already produced, which is the type of material used in this thesis (MacQuarrie, 2010). Firstly, a documentary is used to explain the innovation process of the low cost sanitary napkin production machine. This is different than academic movies, as it takes years and thorough research to make a film that will be shown in classrooms instead of movie theatres (Shrum & Duque, 2008). The director of the film, Amit Virmani, is from Indian origin, but studied and lives abroad, and from this position, Virmani started to make a documentary about a man with a background contrary to his own – an illiterate man from rural India (Menstrual Man, 2012). The documentary provides a good understanding of the context in which Muruganantham worked on this innovation. For instance, it is easier to understand through visual representation the physical environment, the constraints and opportunities there.

Besides the process of making and the actual content, also the reaction of the audience is covered in the study as reflexivity is an important aspect for trustworthiness of the thesis (MacQuarrie, 2010). The documentary received praising feedback and has been covered in news articles of BBC and Bloomberg Businessweek. The New Indian Express, 2013), wrote for example: “One of the high points of the film was the presentation of such a strong message in a humorous way.”

Additionally, there are video recorded talks of the innovators telling how they developed the innovations. Mr. Mansukhbhai talks in a TED Talent Search event about the Mitticool

refrigerators, Muruganantham gives a TEDTalk and an INK Talk about the production machine producing low-cost sanitary napkins.

3.3 Data analysis

The data for each case was firstly organized as a separate resource package in a case record. The analysis of the data was ongoing simultaneously with the data collection and organizing the data. While eventually adding relevant data into the case record, the researcher familiarized herself with the data available, which was also important for the beginning of the analysis process. (Eriksson & Kovalainen, 2008, pp. 127–128).

While editing the data, within-case analysis technique was utilized to familiarize with the case study and see unique patterns emerging. A descriptive text with thick descriptions was written as a result of the within-case analysis, during which the researcher gained a deep understanding of the case. This was a useful tool to combine all data found into a more manageable size. The next step was then to look in a cross-case comparative analysis for patterns of similarities and differences in terms of categories and dimensions suggested by process emerging from the empirical data. (Eisenhardt, 1989).

For both the within-case analysis and the cross-case comparison, coding was a practical tool as it helped identifying labels for the data, connecting links within the data and constructing categories. In this research the coding process was based in grounded theory (Benaquisto, 2008). This process started with open coding, identifying the issues and notions in the data. This was followed by a few more rounds of coding during which the most prominent codes were found. During the selective coding phase, codes were grouped into specific categories relevant for the research question. Throughout the analysis process, the researcher made notes of concepts and labels that came to mind, which were in the end an important component in the analytical process towards themes and categories. (Benaquisto, 2008).

3.4 Trustworthiness of the study

It is more complicated to measure trustworthiness of a qualitative study as it aims to explain constantly changing phenomena. However, Given and Saumure (2008) have listed terms which allow explaining the generalizability, validity, reliability and objectivity in the context of qualitative research.

Firstly, as generalizability is complicated in case of qualitative studies it is referred to by Given and Saumure (2008) as transferability, considering the scope and applicability to a broader context. The cases studied in this thesis are all from India, and there is no reason to assume the outcome would have been different had other cases been studied. When choosing the cases, attention was paid to the representation of what was defined as frugal innovations. Therefore the findings can be interpreted to represent frugal innovations at the grassroots level in India.

Internal validity is called credibility when doing qualitative research and the requirements are fulfilled when data is accurate and the phenomena described precisely (Given & Saumure, 2008). Using thick descriptions in the case studies, triangulation of data and reflexivity in the choice of the secondary data sources used are the methods in this thesis to ensure the credibility of the outcome.

Thirdly, reliability is substituted by dependability as the context is changing but with similar means and practises the research outcome should be similar with the outcome of this thesis (Given & Saumure, 2008). The methods used and the rational for the choices made is well explained throughout the process. Consequently, the process is transparent and with applying similar methods to research the findings of other studies should not differ much from the findings of this thesis.

Finally, Given and Saumure (2008) talk about objectivity in qualitative research as confirmability since the findings should mirror the data. Through coding, within-case and thorough cross-case analysis the framework, presented in chapter 7.1, reflects fully the data material gathered. Each argument has a heavy support from practitioner's world.

4 Case studies

The following introduces, the three cases on which the findings and framework towards the end of the thesis are based. The cases are written with thick descriptions to also be able to explain the contextual factors. While writing the case studies and getting more familiar with the case material, within-case analysis was performed. Therefore the text is organized according to the order of the research questions.

The cases are firstly about a refrigerators useful to store food and cool water in areas where electricity is not constantly available. Women need to have the tools to take care of their menstrual health, and not at the expense of the family's food budget. The hand-held milking machine is a hygienic solution for the cow and ergonomic for the person milking the cow.

4.1 Mitticool refrigerator by Mansukhbhai Prajapati

Mansukhbhai Prajapati, a traditional craftsman, grew up in a family living on traditional pottery making. As only and eldest child, his role was to help his father with the clay making, but Mansukhbhai was not very motivated to do so. When in 1979 the Machhu dam broke down, the family lost everything and moved to a near-by city. (Mitticool, 2011).

Mansukhbhai parents encouraged him to finish class ten, however failing the final exams (Economic Times, 2012). After the school year was finished, he started working for a tile manufacturing company to help his family's financial situation. While working inside the chimney, Mansukhbhai's eye got injured and he was not able to work for eight months. Then, in 1984, he started his own tea stall, but after six months Mansukhbhai decided to stop it. While running his tea stall, his uncle came to ask if he knew anyone interested in working in a tile manufacturing company. Mansukhbhai himself was, and after he quit working with his own tea stall, he joined the tile manufacturing unit of Jugdamba Potteries, where he learned during three years the skills related to the work of tile manufacturing. (National Inovation Foundation, 2009).

At his job in tile manufacturing Mansukhbhai used a hand press machine to make tiles in large quantities. Previously in his village earthen pans and hot plates were made manually and in smaller quantities. While working at the tile manufacturing unit, he started experimenting with the hand press machine to modify it to make pans. In 1988, Mansukhbhai left the tile

manufacturer to start his own enterprise making 700 clay pans a day with the modified hand press machine to make pans. (Mitticool, 2011).

4.1.1 Research

Mansukhbhai took a loan of 500 USD (₹ 30,000) from an informal money lender, bought a piece of land and the necessary equipment such as dyes and presses, soil mixing machine and the electric potter's wheel. In eight days he had built up the plant and started to manufacture 50 pans in a day in his factory. Mansukhbhai put them in a container and went on his bicycle to the villages to sell his products. This went on for a while, but he started to get feedback from his customers, that the pans were breaking if heated too hot. As a consequence of this he first lowered the price, but when that was not satisfying the customers he started experimenting with different proportions of different type of clay to find the appropriate mix. (National Innovation Foundation, 2009).

By 1989, the production amount had increased as Mansukhbhai started using the electric potter's wheel and presses. Therefore he had to rent an auto rickshaw to sell his pans to villagers. The following year, Mansukhbhai registered his manufacturing plant Mansukhbhai Raghavbhai Mansukhbhai at DIC, Rajkot. In 1992, he received his first bulk order from a visiting trader from Bhuj. During the following two years he was completing more retail and bulk orders from Bhuj, and through that managed to pay off his loan. In 1995 a trader from Rajkot came to him after following the recommendations from his former employer Jagdamba Potteries. The business man was looking for a water filter, which he did not manufacture at that time. Within 8 days a water filter was ready. The quality was above the expectations of the trader and he received double the price as initially agreed on, and so he made 500 water filters for 3.30 USD (₹ 200) a piece. (National Innovation Foundation, 2009).

In 2001, a devastating earthquake happened in Gujarat, also destroyed the whole stock of Mansukhbhai. In a newspaper he saw a picture of a water filter manufactured by him, but in the caption it was referred to as "the broken fridge of [the] poor". This triggered him to actually start working on a refrigerator made out of clay, which would function without electricity and thus be accessible to the many rural people to store for instance vegetables, fruit, water and milk. The design and development process lasted 3 years, and in 2005 his first large order from

a civil engineer of 100 refrigerators for 3340 USD (₹ 200,000) was local news. (Mitticool, 2011).

In the many years of development, Mansukhbhai struggled to get the right combination of different types of clay. He finally developed a mixture of four different types of clay to create a refrigerator that stays cool in dry climates (The Permaculture Research Institute, 2013). Sawdust and sand were the key to success as they make the soil absorbent and keeps the interior cool (NDTV, 2011). All raw materials are sourced locally from the area where Mansukhbhai is working (The Permaculture Research Institute, 2013).

Mansukhbhai has made two versions of Mitticool. The first version had two water chambers whereas the later version only one. The first version had a capacity of 20 litre of water and space to store up to 3kg of food, and it was sold for 25 USD (₹ 1500) only until a better version made it to the market. In the second version the water container is half the size, but there is space to store 5-7 kg of food. (National Innovation Foundation, 2009).

4.1.2 Partners

During the development stage Mansukhbhai had taken a loan of 11 670 USD (₹ 700,000), including interest it grew to a total of 31 670 USD (₹ 1,900,000), and therefore he was forced to sell of his ancestral home to pay off the interests (Hindustan Times, 2014). A turning point in the Mitticool development process is, when Mansukhbhai was acquainted with NIF and its vice chairman Anil Gupta in 2006 (Economic Times, 2012). Having a huge financial burden, Mansukhbhai received financial support of 3340 USD (₹ 200,000) for the business from NIF and four years later the business reached the breakeven point (Economic Times, 2012). Besides financial security and the possibility to expand the business, the financial support also boosted his confidence (Hindustan Times, 2014). The business is expanding steadily at around 15-20% annually, with sales of 75 000 USD (₹ 4,500,000) in 2012-2013, and on a monthly basis 230 refrigerators are sold (Hindustan Times, 2014).

GIAN and NIF supported Mansukhbhai with testing, product development, intellectual property protection and business development. The clay and the final product were tested at the Institute of Chemical Technology University of Mumbai and Krishi Vigyan Kendra, Bharuch. GIAN and NIF also assisted with value addition, fine-tuning the product and

packaging for transportation. Additionally, Mansukhbhai was helped with overall business development, marketing and networking. Furthermore, the trademark was designed and registered with the help of GIAN. (Grassroots Innovations Augmentation Network, 2008b).

In addition to the above mentioned, GIAN assisted greatly in the patent application process. Even though combining clay with oxidizer was already in use, the mixture for Mitticool was unique and therefore it is protected through the design registration since 2007. In the development process Tata Chemicals in Pune was also involved, improving design to ensure a longer preservation of food. The Industrial Design Centre (IDC) of IIT Mumbai and other professional designers were approached to assist with the design to ensure a product appealing to the eye and ergonomic to use. Mansukhbhai received technological support furthermore from GIAN and NIF, and through their network also from Sardar Patel Renewable Energy Research Institute (SPERI), L.D and the Engineering College Ahmedabad, for example. (Trivedi, 2011).

Table 1 Total manufacturing cost of Mitticool. (Trivedi, 2011).

Material cost	8 USD	₹ 480
Accessories	9 USD	₹ 550
Labour	10 USD	₹ 600
Indirect expense	11 USD	₹ 635
Total	38 USD	₹ 2265

4.1.3 To the market

Most importantly, NIF through GIAN offered financing to Mitticool as during the rainy season there were no fairs and the incoming cash flow was low. Above that GIAN offered services worth 20 USD (₹ 12 000) to the project. He paid the loan back within two years. The greatest challenge for him was marketing and sales, and also for this GIAN assisted by registering the company “Clay Creation” in 2008 and establishing a sales channel through the Big Bazaar outlets since 2011. (Trivedi, 2011).

All the hard work paid off, when Mansukhbhai was in 2009 awarded with the Technological Innovation and Traditional Knowledge Award (National Innovation Foundation, 2009). A year

later Mitticool received USD 8340 (₹ 500 000) assistance from the MVIF for commercialization of the product (National Innovation Foundation, 2014).

A sales channels for the refrigerator is through the online store, the development of which GIAN has also supported. Mansukhbhai has also presented his products at the Saatvik – the Traditional Food Festival in Ahmedabad. There he also got new ideas for products and improvements of existing ones. An important channel for feedback is from his more educated friends. His wife is responsible for the sales of the many products. Together they market the products and participate in exhibitions. However, his main interest is experimenting and developing new products. (National Innovation Foundation, 2009).

4.1.4 Future ambition

By 2012, Mansukhbhai had sold over 3500 Mitticool refrigerators, and his enterprise is employing 25 employees, of which most are women. (Society for Research and Initiatives for Sustainable Technologies and Institutions, 2012). Besides the Mitticool refrigerator and the water filter, Mansukhbhai has also developed a non-stick pan and a pressure cooker out of clay and his next ambition is to make a Mitticool home, which does not require any electricity. (TedTalentSearch, 2012).

4.2 Low cost sanitary napkin by A. Muruganantham

Already in school Muruganantham was fascinated by science, which his teacher gladly supported. Living in rural India, his hobby was to visit after school friends living on farms and study, modify and repair the farming equipment. As a young boy, he lost his father and therefore, after ninth grade, he had to start working to help his mother with supporting the family. He worked for instance as a technician, with machines and on farms. (National Innovation Foundation, 2009).

Muruganantham got married in 1998 and in his early marriage days, he saw his wife carrying a dirty rag. He inquired what it was, but she bluntly announced it was not his business. Finally he understood that she was using it for menstruation. From her he learned about the embarrassment during menstruation dealing with dirty clothes and came to understand the dilemma of whether to buy sanitary napkins or milk for the family. (TED talk, 2012).

He realized that his wife was not the only woman who was suffering during menstruation, and he wanted to learn more. The next day he went to buy a package of sanitary napkins for his wife. Muruganantham was surprised that the price of such a simple item, with low material costs he thought, could be so expensive. Additionally, it was astonishing for him, that the seller wrapped the package into newspapers, which made him feel like he was buying something illegal. Then he got the idea to make a low cost sanitary napkin for women like his wife. (TED talk, 2012).

4.2.1 Research

Muruganantham was sure he was able to make a sanitary napkin at an affordable price, but for his research aiming to understand sanitary napkins he needed women to volunteer. He first asked his wife to help him. He needed more volunteers to speed up the process, as menstruation happens only once a month. Therefore he asked his sisters to join as volunteers. The women in his family were however embarrassed to cooperate in the project, and the initial feedback from his wife was negative. Muruganantham then decided to approach female students of the medical college, and 20 students agreed to participate in the research albeit it did not go without obstacles. Firstly, it was not easy for a workshop worker to approach the female students on campus, and even the future doctors were embarrassed to talk about menstruation. And when he suggested feedback forms, he found out that three girls were filling in the sheets of the other girls as well. (INK talk, 2011).

The only solution he could think of then, was to try the prototyped napkins himself. Putting animal blood in a football tube, he walked around and cycled to test the functionality of his design. Muruganantham was not satisfied, and after almost one year of research he still did not know why his sanitary napkins were not working. As a negative consequence of his research, the people around him thought he was losing his mind and his wife left him. (INK talk, 2011).

Since he still wanted to work with the issue, he took a risky step and asked girls from the medical college for their used sanitary napkins. He gave them the napkins in a plastic bag, and asked the girls to put the napkins back in the bag once used. He collected them pretending to be working for municipality. At home, Muruganantham spread the used napkins on the floor to examine them. When his mother saw the collection of used napkins on the floor, she also

left him. However, after two years and three months of research he finally understood how the napkin works. (Menstrual Man, 2013).

Muruganantham started with cotton, as he thought that was the raw material of branded sanitary napkins. He approached a professor at a local college to help confirm his assumption. Together they wrote letters to the multinationals and searched online for suppliers. In the process he learned English, and managed to call suppliers in the U.S. Muruganantham was pretending to be a millionaire from Coimbatore establishing a business in Southern India and in need of raw materials. He then got samples and finally found out that the raw material used was wood fibre, which is advantageous for the drainage of fluids and for maintaining the shape. (MinnPost, 2010).

Understanding the raw materials, Muruganantham realized that the cost factor comes from the expensive machine the multinationals were using, but even that did not discourage him (INK Talk, 2011). Muruganantham conducted an additional four and a half years to finish the machines used for the production (Menstrual Man, 2013).

Muruganantham was working alone, on his personal yet constraint budget, and the process included a lot of trial and error. His aim was to achieve a production process simpler than the processes used in multinational corporations. The components for the machine he received from fabrication shops in Coimbatore. (Narasimhalu & Dula, 2012).

The innovation process for the machine proceeded in the order of the manufacturing process. The raw materials Muruganantham decided to use for the final product are besides wood fiber, also barrier film, release paper, super bond paste and plastic for the packaging. Then next, Muruganantham developed the defibering unit to process the raw materials and to get the right size and shape for the sanitary napkin. The production unit works on a small motor. This was followed by the forming unit, which is made out of aluminium and powered manually. The machine allows the production of two different types of sanitary napkins, either with equal fibre density or varied density. Another machine seals the sanitary napkins, and it is operated manually with a small motor. The sanitary napkins are sterilized either manually through a UV lamp or in the sterilization unit. The first version of the production machine was ready in 2004, and he gave samples to his neighbours to test and evaluate the product. For the next version, he added a sterilization unit, improved the ability to make napkins in different sizes and

increased the capacity that the daily production could go as high as 1000 pieces a day. (National Innovation Foundation, 2009).

Once Muruganantham was satisfied with the end product, he sent it to the Indian Institute of Technology in Madras for evaluation. Without his knowledge, IIT-M included the production machine as an entry of an innovation competition called Best Innovation for the Betterment of Society, also organized by IIT-M. Muruganantham eventually won the prize, after which he received a lot of feedback. From the long research process he had also learned a lot and gained new skills. So he understood the value of intellectual property rights as his innovation was unique in the world. Muruganantham was granted the patent of his innovation. However, through observing business men he had learned about doing business and decided to use his innovation for a social cause instead of making only profit. (INK Talk, 2011).

4.2.2 To the market

It was year 2005, when Muruganantham had the final product ready. A year later he established Jayaashree Industries, and 2006 was also the year he won the IIT-M competition. The attention that came with the victory motivated his wife to return. However, the sales were non-existent. Finally, his wife decided to start selling the products herself, and by 2007 the demand had increased enormously. Muruganantham understood, that in order to achieve a 100 % penetration rate of sanitary napkins, the entire process had to involve more women. (Narasimhalu & Dula, 2012).

Getting funds were a problem during while developing the innovation (TED Talk, 2012). Muruganantham received support from NIF from their Micro Venture Innovation Fund in total 14 500 USD (₹ 870 000) during the financial year 2007-2008 or the diffusion of the product to different states in India (National Innovation Foundation, 2014). In 2009, Muruganantham was awarded with the National award for Grassroots Technological Innovation and Traditional knowledge.

Once the product and the machine producing the sanitary napkins were ready, the challenge was educating women and society about the usage of sanitary napkins during menstruation. There were many wrong beliefs that lead to women staying at home for five days in a month or girls dropping out of school. Therefore Muruganantham created what he called “a low cost

sanitary napkin movement” to spread awareness of both the product available as also against the wrong beliefs. He thinks it is important to talk about this issue with young people, and visits universities and colleges. Muruganantham also wants to inspire youngsters to use their educated brain to create something new instead of working only to survive. (Menstrual Man, 2013).

Women themselves living in villages are also an important component of the success of the business. Muruganantham aims to spend at least three days a week in remote areas installing the machine and educating the women. When Muruganantham goes to a village, he does not buy a return ticket, thus there is no stress nor time pressure. Despite the offers he receives by distributors or venture capitalists, he has not changed his model from rural to urban women. Neither has he changed his mission from creating livelihood for rural women to money and profits. (Menstrual Man, 2013).

It takes one day to teach how the machine works and, as the machines are very simple, women will also quickly understand how to fix and maintain themselves (Menstrual Man, 2013). It is for this reason that he has decided to provide all information online (Jayaashree Industries, 2011), including a list of the cost of raw materials and potential profit (Table 2).

Table 2 Material expenses of the production of 8 napkins, including packaging. (Jayaashree Industries, 2010).

Material	Total cost for one napkin	
Core Material	₹ 3,70	
Top Layer	₹ 2,00	
Barrier Film	₹ 0,35	
Release paper	₹ 0,20	
Gum	₹ 0,30	
Packaging	₹ 0,60	
Total	₹ 7,15	
<i>Including wastage, labour and power</i>	₹ 10,00	<i>USD 0,16</i>

4.2.3 Future ambition

There are currently machines in 1300 villages in 23 states. The women producing the sanitary napkins create their own brand name for the napkins, which they also sell themselves. Experience has shown that hence the sensitivity about the menstrual period, women prefer buying from other women, who are then also in the position to spread important information about hygiene and the reasons for menstruation. A production plant costs 1 250 USD (₹ 75 000), and employs around ten women, producing 200 to 250 napkins daily, which are sold for 0,04 USD (₹ 2,50) per piece. (BBC, 2014).

The success of the business is relying mostly on word of mouth. As it is a problem worldwide faced by women, the machine has reached the interest through word of mouth also in other developing countries (BBC, 2014). The mission of Muruganantham originally was to employ one million rural women in the production of low-cost sanitary napkins (INK Talk, 2011). Later the ambition has grown to employing 10 million women world-wide (BBC, 2014).

In 2008 Muruganantham developed a vending machine with 25 sanitary napkins, which would be readily available in public buildings such as hospitals and colleges. The inspiration for this type of machine was seeing how easily money came out of ATMs to satisfy the need of the people for cash immediately. (National Innovation Foundation, 2009).

4.3 Milking machine by Raghava Gowda

Raghava Gowda is a school teacher from a village in southern India. He was also an owner of a cow, which needed to be milked every day. The milking of the cow was neglected as there was not enough time to keep her clean, and the cow got an utter infection. Gowda himself got a strained nerve in his hand from the daily milking. The only thing he could do in that situation in the early 2000s was to sell the cow. However, he started thinking about a solution for a more hygienic and ergonomic milking machine which would be a less time-consuming and a low cost milking process. (Outlook India, 2005).

As a starting point to the challenge he also saw the dilemma between finding labourers with the skill of milking and the high cost of an imported milking machine. Gowda decided to develop an affordable milking machine for all and as a result of that the Milking machine was developed, which could milk 1.5-2.0 litre of milk in a minute. The machine consists of “reciprocating vacuum pumps with a vacuum gauge, a suction assembly unit and an air bubble-

free canister with a gasket” for the milk collected. The machine is able to remove all the milk from the cow, and the cow does not suffer any pain during the exercise. (Honey Bee, 2004).

4.3.1 Research

Gowda started his research process through observations. He got inspired by the Gutter spray pump which is used to spray insecticides to avoid insects. An important challenge he took into account since the beginning of the development process, was the scarcity and availability of electricity. That was the reason why he originally started to develop specifically a hand-held milking machine as there was no such machine yet on the market. (Datt, Jha, Tak, & Salaria, 2013).

In 1999, Gowda took a sabbatical year from teaching, a profession many in his family are working in, to focus on the development of a low cost milking solution. He paid for a substitute teacher, as he felt responsible and did not want the school children to suffer from his innovative mind set. He also invested 3 340 USD (₹ 200,000) into the project and also received financial support from other family members. From his brother he received 840 USD (₹ 50 000). His son-in-law played an important role besides financial assistance also in market entry activities. (India Today, 2008).

The entire product development of the machine took four years, during which he developed 15 different models until he was fully satisfied with a flawless product. Gowda started with PVC teat cups, which were moulded to fit the size of the teats, and with a Gutter pump plastic pipe, which was heated. This solution was painful for the cow due to the excessive vacuum. (National Innovation Foundation, 2005).

After the first model, Gowda was disappointed and discouraged, and it was only the motivation from his family and other supporter that kept him going. To continue his research he started visiting other farms’ dairy units to study their milking machines. Through this, he learned more about the vacuum principle, and continued working with that. (The New Indian Express, 2012).

The experimenting of the machine took place on his own farm, with the support from his family (Bhandari, 2011). The challenge during the innovation process and later also for manufacturing in the workshop, which is located in his village, is the availability of electricity (Bhandari,

2011). Despite the inconsistent electricity supply to the village, the main reason for staying there is to keep the costs low and thus the price affordable for the users. (The New Indian Express, 2012).

For the next prototype, the vacuum container was adapted and therefore it was also possible to milk from four teats simultaneously. Then he added a foot press mechanism, and placed the vacuum press on four legs. In a later stage it turned into a three leg frame to ensure better balance. Additionally, to measure the vacuum generated, a vacuum level gauge was added to the milking machine. (National Innovation Foundation, 2005).

In the next phase, a gear and a wheel were added to the vacuum pump to create a portable solution and to ease the milking exercise for the user. The material of the can, the lid and the teat adaptors was also changed from plastic to stainless steel. The last modification to further ease the use of the milking machine was alternating the pulsing for each set of two teats. The final product, which was sold on the market for 116 USD (₹ 7000), can be entirely disassembled for cleaning. (National Innovation Foundation, 2005).

Over the years, the milking machine has developed from Manual Milking Machine to different type of machines with a variety of power sources. These are Semiautomatic Milking Machine, and motorized Double Cluster Electrical Milking Machine, Single Phase Ac Motor Milking Machine and 12 Volt Battery Driven Milking Machine. The higher advanced power source, the more expensive the device and the price varies between 189 USD (₹ 11340) and 637 USD (₹ 38210). (Society for Research and Initiatives for Sustainable Technologies and Institutions, 2012).

4.3.2 To the market

The media coverage of the Milking machine was positive, and through that Gowda received many contacts from interested customers. Gowda has received the state award from NIF for his innovation in 2005 (Ksheera Enterprise, 2015). From the University of Agricultural Sciences in Dharwad he received a certificate and the Syndicate bank in Hiriyadka also awarded him with a certificate for his innovation (Bhandari, 2011).

During the financial year 2009-2010, Gowda received in total USD 8340 (₹ 500 000) support from MVIF for commercialization of his product (National Innovation Foundation, 2014).

Each part of the milking machine is supplied from an external vendor, and thus Gowda is dependent on his suppliers and needs to have a stock readily available at all times. (Bhandari, 2011).

Ksheera Enterprise was established in 2004 for manufacturing the milking machine and selling it to farmers at an affordable price. When it comes to the sales channels, the latest development is that NIF on behalf of Gowda and Gujarat's Aviva Equipment Pvt Ltd have made an agreement on the non-exclusive marketing rights for Gowda's 'Milking machine'. (Tribune India, 2014).

Besides offering high quality machines at a low cost to users, the Ksheera Enterprise provides since 2003 employment to local staff and engineers. Some 30 engineers have been trained to work for the company. Being based in the home village of Gowda, the young men of the village can thus stay with their families instead of leaving to nearby cities to look for work opportunities. (Ksheera Enterprise, 2015).

By 2012, Gowda had sold 3000 milking machines. The first customer of Gowda was a veterinary doctor, and since the word has spread through word-of-mouth from village to village across India. When buying the milking machine, the users receives also a repair instructions on a CD and therefore users are able to maintain the machine themselves. The milking machine has made it a feasible alternative for people living in very rural areas to keep livestock. (The New Indian Express, 2012).

There is interest for the low-cost milking machine abroad, not only from the neighbouring countries but also countries like Kenya and Sweden. The assembly line produces 250 of machines monthly, but the manufacturing plant has the capacity to produce 2000 machine a month. The grand mission of Gowda is to reach every farmer in India. (Ksheera Enterprise, 2015).

Farmers can get subsidy from for instance Bangalore Milk Producers Federation and Kolar Milk Producers Union on the milking machines made by Gowda. He argues, that livestock

prosper when a state with a subsidy scheme. Gowda has also seen cheaper copies of his milking machine entering the market. However, these imitations are not near to the high quality of the milking machine developed and produced by Gowda. He does not see the copycats as a threat. (The New Indian Express, 2012).

The innovation has been patented, and some commercial institutions have wanted to buy it, but Gowda has made a principal decision that his innovation will not be used by a profit making firm. He created the milking machine for himself and hopes to benefit other small farmers instead of a firm. The sales channel is mainly direct sales to interested farmers who contact Gowda. He believes that buying the Milking machine will also improve the life of the farmer. (India Today, 2008).

4.3.3 Future ambition

Gowda is very innovative and has also developed some other solutions to problems found at his farm, such as a biogas digester that collects gas from degradable food waste, a fodder cutter that is able to cut also very hard material and waste slurry as fertilizer on his farm. In fact, he created his first innovation, a bamboo and noodle-press spray gun, at the age of ten. Moreover, even after the milking machine was developed, he didn't want to stop innovating but continued solving problems to ease the work of farms. (National Innovation Foundation, 2005).

Gowda says that his hard working attitude, honesty towards his parents and compassion have helped him to become a successful innovator. He is also getting very much respect from other villagers, and for his innovations he is already a legend in his village. Another challenge is the availability of skilled labour for his manufacturing plant. (Bhandari, 2011).

The operations of his firm have attracted his daughter and son-in-law, who is an electrical engineer, to move back to the village and they help Gowda in running the firm. Another daughter and her husband take care of logistics from Bengaluru. Gowda's wife is considering to stop with her daily job as a teacher to help her husband at home. (The New Indian Express, 2012).

The innovator has high aims, and he talks about a "white revolution". He hopes that the machine acts as an encouragement for unemployed people to seek for jobs. The milking

machine is simple and the price is low, it decreases the ergonomic burden of milking and the end product is good milk which is produced hygienically. (Society for Research and Initiatives for Sustainable Technologies and Institutions, 2012).

5 Analysis

In this chapter the similarities and differences of the three cases are highlighted. It starts with a discussion on frugal innovations to confirm the case studies fulfil the requirement of the definition. This is followed by the innovation process from idea to market entry, covering also the challenges and the partners in the process. Finally, the impact each innovation has had on its environment is analysed.

Before the actual writing process started, extensive coding and categorizing took place. Here, the outcome of the cross-case analysis, is divided into categories reflecting the research questions.

5.1 Frugal innovations in the local context

The frugal innovations studied in this thesis fulfil the definition of frugal innovations built on exiting theory presented earlier. Each of the three innovations can be called a novelty product due to the innovative clay mixture used, the way machines produce sanitary napkins and milking a cow has been made easy. Additionally, the fact that the innovations have been awarded patents in India shows they are novelties in their league. Environmental issues have been taken into account by choosing durable materials such as stainless steel, using recycled components for the sanitary napkin machine and sourcing raw materials locally when it comes to clay.

The innovators aimed for a simple solution, with features that only add to the usability of the product rather than merely making the final product more expensive. The user of the innovation is more often than not an illiterate person living in a village, and therefore the refrigerator, sanitary making machine and milking machine need to be easy to use and with little training. Likewise, for Muruganantham it was important to make a simple machine which is also easy to maintain and repair in case it gets broken. Gowda wanted to make a machine which could be entirely disassembled and be possible to clean. Mitticool had the possibility to use expertise from a designer to make the product look appealing. However, the service was paid for by external funds and thus had no effect on the retail price, yet the attractiveness to purchase an object such as a refrigerator being relatively central in a home, might have increased.

Additionally, the situational conditions were similar for all three innovations. Firstly, the existing products on the market were too expensive, thus the poor could not afford them and therefore the innovator developed a more affordable product. Secondly, they aimed to deliver social benefit to the underserved in rural areas. As all the three innovators came from rural India, they knew the realities there well, and with their innovative approach were able to answer to the needs of the rural population. Thirdly, the innovators did not want to compromise on quality even though the product was aimed at poor people but rather provide a quality product at a low price. Finally, the innovations emerged in the emerging market context and are meant primarily for the emerging market context.

5.1.1 Reverse and disruptive frugal innovations

The innovations studied in this thesis have the potential to scale up from their original villages to India and the wider developing world. However, the frugal innovations can also eventually become reverse innovations and disruptive innovations. In order to become reverse, there has to be a need for the product developed in a developing country also in the developed world context. And it can only become a disruptive innovation, if the new technology revolutionizes the entire industry. Currently refrigerators, sanitary napkins and milking machines have well established markets in the west. However, the frugal innovations studied in this thesis may also become reverse or disruptive innovations with new and surprising ways of using.

Nevertheless, the innovations in the cases studied have potential also outside the emerging market context also as such. Gowda has already sold some milking machines to Sweden. Mitticool has potential to gain market share also in the developed world. If the price of electricity increases in the future as predicted (European Commission, 2014), products which do not require electricity at all might become attractive for consumers also in Western countries. Additionally, for instance summer cottages with no electricity there is a niche market for Mitticool refrigerators.

However, when it comes to the sanitary napkins, it is difficult to believe there would be a market for his machine in a Western country. However, the vending machine for sanitary napkins Muruganantham made after the production machine inspired by an ATM, has potential also in developed country. Having a vending machine with sanitary napkins available in a public toilet can be a great relief in case menstruation surprises women.

5.2 The innovation process

The innovation process in all three cases flows from idea to development and research until the final product is ready. However, the differences arise when talking about the challenges faced during the process, the partners in the process and market entry strategies. Additionally, the sources and availability of funding for the process is unique in each case. Next the cross-case analysis of the three cases in terms of innovation process is presented.

5.2.1 The innovator and the idea

The three innovators studied have in common the desire to create something new and innovate since a young age. Besides the innovations studied in this thesis, the innovators have developed other innovations before and after the refrigerator, sanitary napkin or milking machine. The new innovations were related to the same field as the previous innovations, thus remaining in the field of kitchen equipment made out of clay, sanitary napkins and farming equipment.

The level of education completed by the innovators differs. On the one hand there are Mansukhbhai and A. Muruganantham, who both have completed only a low level of education since they had to start working in order to help in supporting the family financially at a young age. On the other hand, Raghava Gowda became a teacher.

The skills required to use equipment and built machines were learned in previous jobs or during free time activities, and the innovations were in all three cases technological. Mansukhbhai learned to operate the hand press machine to make piles while working in the tile manufacturing unit, and Muruganantham learned to understand machines while studying his friends' farming equipment as a school boy. Gowda milked his cow every day, and therefore knew the practice and could understand cows very well.

The existing product on the market was not affordable for the rural poor. A refrigerator was out of the reach for the reason of lack of energy, sanitary napkins were despite their small size and light weight not affordable, and an automated milking machine was extremely expensive for a rural farmer. The idea of all three innovations was to create an affordable solution to the problem.

Additionally, the idea for the innovation emerged originally to answer to a problem identified within the family or the village. However, the aspiration to start working on the innovation came from the innovator himself. Gowda saw, that a low-cost milking machine was needed to speed up the milking process, to make milking easier and to have a safer and more ergonomic option for both the cow and the person milking. Muruganantham wanted to impress his wife, ease her burden during menstruation and provide her with a hygienic alternative for the dirty rag she was using. Soon he realized, that a sanitary napkin is very light yet too expensive for many women, and so he got the idea to develop a low-cost sanitary napkin for women who could not afford a sanitary napkin made by multinationals.

Mansukhbhai started in 1988 making clay pans with a modified hand press machine he learned to use while working in the tile manufacturing company. The business was going well, and by chance in 1995 he accepted an order of water filters, which he was not yet producing at that time. Then, in 2001, after the earthquake which hit North-West India, Mansukhbhai saw a picture of a water filter produced by him but it was called a refrigerator. Thus, he got the idea to develop a box out of clay, which could be a refrigerator keeping food cold without using electricity.

5.2.2 Challenges in the process

The process from idea to final product was in all three cases long. For instance, it took Mansukhbhai eight days to build the plant to make pans and equally so eight days to make a water filter, but the development and research for the refrigerator took three years. Muruganantham used first more than two years to understand the material which was used in sanitary napkins produced by the multinationals. He then used an additional four years to develop a machine to produce low-cost sanitary napkins. Gowda used four years and developed 15 models before he was satisfied with the final product.

A number of challenges hindered and slowed down the innovation process. The development of the Mitticool refrigerator was not easy due to the complexity of finding the right mix of clay. During the previous product development processes he had received valuable feedback from his customers, and he also created a habit of asking his educated friends for advice and comments. Additionally, during the development, Mansukhbhai had to take a loan, which

turned out to be too big to be paid back when interest was also included. He therefore had to sell the house he and his family were living, causing stress.

The main challenge of Muruganantham was the difficulty to find volunteers for his research to develop a low-cost sanitary napkin. Women did not want to be involved as due to the many wrong beliefs about menstruation, not everyone understood what his intention was. However, the female input was essential, thus with trial and error, and his problem-solving skills he came up for instance with a feedback sheet to avoid an embarrassing discussion about sanitary napkins. Muruganantham continued with the research process even after his wife and mother had left him. Out of desperation he tried the napkins himself utilizing a makeshift bladder filled with animal blood. He finally sent the first sanitary napkin made with the machine developed by him to IIT Madras for evaluation. When his innovation won the competition organized by IIT Madras, it was a guarantee of his good intentions for his wife, mother and other people from his village who had lost faith in him.

Later the same challenge reoccurred as to the sanitary napkins had a low acceptance on the market. The customers needed education about the product and against the wrong beliefs. When Muruganantham's wife returned back to his husband, and started to sell the product directly to women, he realized that women needed to have ownership of the entire process if he wanted the product to be widely accepted and used. Thus, the learning from the challenge he faced, Muruganantham was able to turn into an advantage and the involvement of women is a cornerstone of the success of his business today.

To develop a low-cost milking machine, electricity was needed. However, it was scarcely available and therefore the aim was since the beginning to develop a machine that can be manually operated. There are still challenges when it comes to manufacturing milking machines today, as the skilled labour is not widely available in rural India. Gowda, being a teacher, has decided to educate his workers to be engineers and find employment with his company in their village.

To conclude, the challenges face by the innovators have partially slowed down the process. At the same time, the challenges caused by insufficient infrastructure, such as insufficient electricity supply in rural areas, were taken into account as the final innovation was also a solution to overcome the challenges. For the research in the product development phase, the

innovators used the know-how they had and skills they obtained throughout the process. Additionally, to look for solutions they used the means available and their network. The innovators were also able to use their creative mind to overcome challenges occurring during the process.

5.2.3 Partners in the process

The first big order of Mitticool refrigerators was placed in 2005, and it gained some publicity in local media. Then, in 2006 Mansukhbhai learned about NIF, and with the help of that organization and its chairman Anil Gupta, he received a lot of assistance. The support started in 2007, and the lasted intensely at least until 2011. It has included direct financing through loans and investments but also in-kind support. The financial support also increased the self-confidence of Mansukhbhai.

Mansukhbhai was also introduced to GIAN, which is a partner of NIF. GIAN facilitated many of the practical endeavours in the development process. These include firstly testing of the product and the clay. Secondly, designing the packaging, ensuring appealing looks and usability of Mitticool. Thirdly, assisting with intellectual property rights issues and with the patent application, in addition to registering and designing a trademark. Lastly, GIAN helped with business development by establishing an online store and a relationship with a retailer. Mansukhbhai was also introduced to other partners in the network of NIF and GIAN, which included mostly universities and colleges, but also corporations.

Muruganantham faced challenges with regards to the funding of his research. He was working alone throughout the whole process and therefore also on his own budget. After the innovation was ready and winning the competition organized by IIT Madras, he was also granted Micro Venture Innovation Fund by NIF. The funding was used to spread the innovation to more states in India.

Gowda received financial support from his family, but also invested own money in the development process. He got also recognition from a bank and a university, which triggered positive publicity in the media. Later in the development process he was acquainted through his network with retailers. Furthermore, Gowda's supportive family and wife have been a great help in the efforts to make a low-cost milking machine.

Gowda is also getting financial support from milk unions. They have offered subsidies to farmers buying the milking machine. This has stimulated sales, and been good for the business of Gowda.

The most important partners have firstly been research institutes, which have been able to evaluate and comment on the substance of the innovation. Secondly, those parties organizing competitions. That has been an important route to create awareness of the development of the innovation and to get publicity, which has then again helped in finding partners. However, as the partners were found only after the research was done, they could assist mainly in capacity building on business related matters such as sales channels, IPR and design.

Since the innovators were operating alone, they could not hand over tasks to a team member. Gowda, Muruganantham and Mansukhbhai were in charge of everything themselves. Practical matters such as market research, marketing and contacting distributors entered the picture once the innovation was ready. At the right moment the partners, who are both willing to help and experts with these hands-on issues, entered the picture. Later the innovators also got help in day-to-day tasks of running a business from their family members, such as wives, children and in-laws.

The sources of initial funding and availability of funding throughout the process differs in each case. Mansukhbhai had his business of pottery, and was selling other products made out of clay generating some income from it for the research for Mitticool. Gowda had worked as a teacher and was able to use some of his savings to develop a low cost milking machine. He was also supported financially by his brother and son-in-law. Muruganantham had the worse financial situation of all three as he had no own capital and besides working on the innovation he was also responsible for supporting his family. Despite the financial troubles, all innovations became products which were ready to be sold on the market even before further external assistance. By now, all of the three innovators received funding from the Micro Venture Innovation Fund managed by NIF for the commercialization of the product.

The cases also demonstrate, that the more assistance the innovator has got, the more advanced the brand name and business model is. For instance Mitticool has besides a brand name, its own online store and a beautifully designed product. Support from the family is important although Muruganantham shows that even after his wife and mother left him, he was

determined to continue with his research. A mentor, like Anil Gupta has been for Mansukhbhai, and continuous support for years allows the innovator to concentrate on more innovations instead of having to learn the practicalities of running a business.

5.2.4 Market entry

The first customer was important for Mansukhbhai and Gowda, as they managed to draw positive attention from experts from the field. The first customer for the Mitticool refrigerator was a civil engineer and the first one buying a milking machine was a veterinary doctor. Muruganantham had more trouble finding customers as the product was not accepted on the market, and during the first year he faced many challenges due to a low demand for the sanitary napkins. He had to apply a different strategy and started to involve more women in the diffusion of the product, which eventually led to an increase in demand.

Overall, the word of the product spreads mainly through word-of-mouth and peer to peer marketing. The role of the awards won by the innovators is besides recognition for the many years of hard work also a way to get publicity helpful for marketing and driving away customers' doubts.

The initial approach by customers was thus facilitated by the publicity from the awards which the innovators had received. The attention created awareness for the product and customers started contacting. For instance, Gowda was approached by customers willing to buy a low-cost milking machine. Likewise, Anil Gupta invited Mansukhbhai to exhibit at a fair at the IIM Ahmedabad, where he was working, to market the Mitticool refrigerator. After winning the innovation competition of IIT Madras, the wife of Muruganantham returned to him. This was good for the business as well since the demand for sanitary napkins expanded once his wife took over the selling process.

When Muruganantham discovered the importance of including women in sharing information, marketing, selling and manufacturing, he developed a model in which he sells the machine only to groups of mainly women, who will then manufacture and be in charge of branding, marketing and sales of their products on their own. His primary market is rural areas as then manufacturing would take place close to the user, and it supports employment of women. He

does not want to use distributors nor does he want to sell his patent to a corporation despite the many offers.

For the market entry activities, the innovations have received most of the assistance from external parties. The competitions were organized by organizations such as NIF and GIAN who were also actively looking for grassroots innovators to support them. Thus, the award also led to additional support, besides customers. The funding from MVIF for the innovators was primarily targeted to commercialization and diffusion activities. The network of GIAN has helped Mansukhbhai in starting distribution through Big Bazaar retail chain and establishing an online store.

Additionally, a similar strategy for learning the innovator used throughout the research process, thus learning by doing and through trial and error, is also applied to understand how to act in this new role. Muruganantham has for instance decided to pay personal visit to the villages buying his machine to ensure proper installing and training the women.

Having the right sales channel is important to market and sell the product widely. Mansukhbhai attended fairs and exhibitions since the launch of Mitticool refrigerators. It is a channel for sales and marketing but also a method to collect feedback from customers. To these events he travels together with his wife, who is currently in charge of selling Mitticool refrigerators.

Once the product has been accepted by the market, the innovator also needs to become an entrepreneur and be in charge of the business. This includes daily management activities, accounting and acting as an employer to other workers. Additionally, the innovator is also responsible for maintaining relationships with suppliers and distributors. In other words, the innovator becomes responsible for managing the value chain from raw materials to the user satisfying the user each time again and receiving money in return. When the business grows, the innovator also needs to take actions to expand the business to satisfy growing demand.

Gowda is getting help from his daughter and son-in-law for logistics from Bengaluru, but Mansukhbhai and Muruganantham take care of most of the activities themselves, with some assistance from their wives.

5.2.5 Impact and change created

The impact and social benefit of the products has been widespread within the communities using the products. Since the launch of Mitticool, people living in villages have been able to store food and water for days. After the machine to make low-cost sanitary napkins has been installed in a village, women have found employment and a hygienic solution for their periods. With the use of the milking machine many small farm owners are now able to benefit more from their cows.

Nowadays, all the innovations have been sold widely across India. The Mitticool refrigerator was launched on the market in 2005, and by 2012 Mansukhbhai had sold 3500 refrigerators. Similarly, the sanitary napkin machine was finished in 2005, and after a slow start the demand increased fast. By 2014, the machine was installed in 1300 villages across 23 states of India, which means that on average every week the machine is installed in three new villages. The milking machine by Gowda was ready after four years of research in 2003, and by 2012 he had sold 3000 machines.

All the three innovators are busy with their innovations and companies. Mitticool has continued on the path of innovations and created a non-stick pan and a pressure cooker out of clay. He has benefited greatly from the help he has received from external partners when it comes to business development and establishing sales channels, and that has left him with some more freedom to work on new innovations.

Muruganantham visits weekly rural villages who are interested in buying his machine. He wants to dedicate his full attention to the inhabitants and therefore never buys a return ticket as he lets things happen as they may. Muruganantham is also paying visits to universities and colleges to inspire students to use their education to create something new instead of just working for a salary to survive. Likewise, Gowda is busy working on new innovations, he has spent a sufficient amount of time further developing the milking machine and he is also busy selling his milking machines. The case studies show, that the more assistance the innovator receives, the more time there is to develop more new products.

Despite the success and the money that it could bring, the innovators have not taken offers from corporations to buy their business or venture capitalists to invest in the business. The innovations have all managed to get a patent for their innovation, which grants them full

ownership of the machine but also power against copies and violations of the intellectual property rights.

India is a large country with a huge amount of people living with limited means. The size of the market for refrigerators requiring no electricity, low-cost sanitary napkins and hand-held milking machines is likewise huge. Therefore, the future prospect of the business also look promising.

Table 3 Summary of the innovation process of Mitticool, the low cost sanitary napkins and the milking machine.

	<i>Mitticool</i>	<i>Low cots sanitary napkin</i>	<i>Milking machine</i>
<i>The innovator</i>	<ul style="list-style-type: none"> - Son of pottery family - Working in tile manufacturing - School drop out 	<ul style="list-style-type: none"> - Workshop worker - Curiosity for farming equipment - School drop out 	<ul style="list-style-type: none"> - Owner of a cow - Teacher
<i>The idea</i>	<ul style="list-style-type: none"> - To solve the problem in the community of not having a fridge 	<ul style="list-style-type: none"> - To solve the problems his wife was facing during menstruation 	<ul style="list-style-type: none"> - To solve the problem of slow, painful and unhygienic milking
<i>Challenges</i>	<ul style="list-style-type: none"> - Finding the right clay mixture - High interest on loan 	<ul style="list-style-type: none"> - Finding volunteers - Lack of financing - Acceptance on the market 	<ul style="list-style-type: none"> - Insufficient supply of electricity - Lack of skilled labour for manufacturing
<i>Overcoming challenges</i>	<ul style="list-style-type: none"> - Feedback from customers and educated friends - Sell parental house 	<ul style="list-style-type: none"> - Problem-solving skills - Involving women 	<ul style="list-style-type: none"> - Manually operated machine - Training villagers to become engineers
<i>Partners</i>	<ul style="list-style-type: none"> - Own financial means and loan - NIF, GIAN and their network - MVIF 	<ul style="list-style-type: none"> - Own financial means - IIT Madras - MVIF 	<ul style="list-style-type: none"> - Financial support from family - Milking unions - MVIF

<i>Market entry</i>	<ul style="list-style-type: none"> - First customer a civil engineer - Publicity, Word Of Mouth - Online store 	<ul style="list-style-type: none"> - Wife in charge of selling - Publicity, Word Of Mouth - Direct sales 	<ul style="list-style-type: none"> - First customer a veterinary doctor - Publicity, Word Of Mouth - Direct sales and distributors
<i>Impact</i>	<ul style="list-style-type: none"> - Mitticool home - Patent, for social not profit-making purposes 	<ul style="list-style-type: none"> - Low cost sanitary napkin movement - Patent, for social not profit-making purposes 	<ul style="list-style-type: none"> - White revolution - Patent, for social not profit-making purposes

6 Discussion

This section of the thesis the empirical findings are linked with existing literature. Firstly the concept of local frugal innovations is introduced referring to frugal innovations emerging specifically from the grassroots level and entering the market on a state and national level. This is followed with an overview of the innovation process of traditional innovations compared to the innovation process of grassroots innovations. The challenges faced by innovators in India are reflected with challenges and uncertainties found in literature. The end of the chapter introduces NIF and GIAN as the main partners which helped the Indian innovators in their struggle to enter the market.

6.1 Local frugal innovations

Besides the characteristics listed in the definition for frugal innovations, a few additional features have arose from the study to define frugal innovations emerging in the local context. The term frugal innovation is understood often in the context of a corporation acting frugally. However, frugal products are also developed on the grassroots level on a low budget, with constrained resources and a limited skill set. It is an innovation from someone living in the same environment as the target customer. To emphasize the different context yet participating in the frugal innovation discourse, for the remaining part of the thesis, frugal innovations from the grassroots are referred to as local frugal innovations. The concept is introduced in more detail first.

Local frugal innovations emerging from the grassroots level are mainly technical innovations and machine. The skills needed for this type of product are easily learned by doing and through experimenting. However, the innovation is not considered highly technical. As the three cases show, the innovation is closely linked also to the previous knowledge of the innovator. Additionally, the materials can be found relatively easily as used components in the villages or from a close by town.

Secondly, local frugal innovations are made for the micro-level and on a small scale, instead of aiming for whole India as a starting point. Thus as in the cases presented, the products are made for people living in a village in rural India, from which it expanded naturally.

Since the innovations remained strongly in the hands of their creators as a result of IPR and patents. Therefore also the production of the products and machines, an additional benefit for the rural villages was the employment opportunity in the clay business, building sanitary napkin machines and producing milking machines created by the companies of the innovators. For this reason there is a smaller incentive to move to a city because jobs are available closer to home. Due to the increasing pressure on urban services such as affordable housing, sanitation and waste management, migrants from the rural areas have to live in slums with insufficient health and living conditions (Planning Commission, 2013).

Furthermore, the innovations analysed in this thesis are besides the mere end product, also holistic solutions to an urgent problem. The starting point for the innovation was the inability to store food, absence of hygiene and lack of knowledge about menstruation, and lack of means for semi-automated milking. The outcome was besides the tangible innovation also the ambition to create a “Mitticool home” thus a home filled with products made out of clay, a “low cost sanitary napkin movement” to encourage every woman to use sanitary napkins during menstruation and a “white revolution” in the milking industry like what the green revolution did in agriculture.

For example, the actual innovation by Muruganantham is besides the low cost sanitary napkin and the machine to make napkins, also the business model selling to self-help groups and women groups empowering women. As a consequence of that Muruganantham is with his inspiring story triggering change in society to be more accepting of problems faced by women. Inclusiveness and participation by women are essential parts of the business model, and his ambition is to give employment to a million women in India and ten million women globally.

Mansukhbhai is an expert in clay making and on a path to create a style of living from using only clay made kitchen equipment – besides a refrigerator also a non-stick pan and a pressure cooker – to a Mitticool home, which would require little electricity. With the milking machines created by Gowda, even poor farmers living in remote areas are able to get the full benefit of the cow they own by milking the udder empty easy and fast. This increases their self-sufficiency in an environment with limited opportunities.

6.2 The innovation process

The linear innovation model is often seen as a conceptual model and used mainly for instance for statistical purposes. This could be understood that the idea will change during the process, but in the case of a local frugal innovation the idea is stable. It is the driving force and the innovator has determination, motivation and passion to find a solution to a problem emerging from the community living in. The other steps in the process of developing local frugal innovations are less structured compared to the model presented in literature.

Below a thorough overview of the innovation process presented in literature compared with the process in case of local frugal innovations. Finally based on the findings, four propositions relevant for the context of local frugal innovations, are presented.

6.2.1 The idea and innovator

In the theory on innovation processes presented by Rogers (2003) and Utterback (1974), science is strongly present as both the initiator of the idea and the innovator. Rogers (2003) additionally notes that the public agenda and social problems are a trigger for innovation. Utterback (1974) highlights that external parties such as consultants also have an influence on the generation of new ideas, in addition to the personal network, education and experience of the innovator.

In the case of local frugal innovations, the innovator operates alone and is therefore simultaneously consultant, researcher and engineer. Local frugal innovations do not need an external consultant to provide an idea, but instead the innovator is the owner of the idea to develop a solution to a problem seen with own eyes. He needs to do the research to understand the technicalities. This happens mainly through trial and error, personal experiences and learning by doing, unlike scientific methods (Rogers, 2003) or high education (Utterback, 1974) presented in innovation literature. Additionally, the innovator is also the engineer building the final product. Local frugal innovation are mostly technological as the skills to build a machine are easy to learn by doing and experimenting.

The innovator for local frugal innovations is developing a product which he or his near family would be using, and is therefore very familiar with the urgency of the need. Personal network and experiences play a role in generating the idea. Education only to a smaller extend, as the

innovator more often than not has a very low level of formal education. Instead, the idea for an innovation is related to a field the innovator is familiar with, thus he can use the skills acquired earlier to the benefit of the development process.

6.2.2 Development

Rogers (2003) talks about scientific and practical research, and adds the notion of serendipity referring to ideas for innovations appearing occasionally when researching something else. Local frugal innovators have only a short career as a student and living in rural villages, they have little access to scientific research. Therefore the research is mainly practical, seeking answers to for instance finding the right raw materials or the most appropriate combination of tools to construct a machine.

Besides research and building the final product, the local frugal innovators do not spend much time or other resources on issues such as design or marketing, which in the model by Utterback (1974) is part of the problem-solving stage. The aim in local frugal innovations is to create a simple and easy to use product, and appearance is only of secondary importance. Additionally, the innovators do not have the skills nor means to improve design or packaging related issues. Only when external assistance is available to help with these issues at no expenses for the innovator, will they be taken up. However, it is also unclear how much the customer values design when the priority is on high performance for low costs.

The financial means of the innovator himself are rather limited, and the support from outsiders is little in the beginning of the process. However, with USD 15 000 a local frugal innovator is able to achieve a lot and small amounts can create a huge return.

6.2.3 Market entry

Preparing the market for the new product in the model by Utterback (1974) and acceptance in the model of Rogers (2003) are important for the final diffusion of the product. Utterback (1974) highlights the importance of personal network to share information and further develop the market for the product.

Both the model by Rogers (2003) and Utterback (1974) have a separate stage in the innovation process dedicated to commercialization and implementation. The market entry of local frugal

innovations happens suddenly and in an unstructured manner. The first paying customer is important, as the marketing happens mainly through word of mouth and peer to peer marketing. When the first customer is an expert from the field or a person respected by the target market, the reputation of the product is boosted.

For local frugal innovations, the main strategies for market entry were recognition from high profile institutions, the awareness formed from publicity around awards and educating of customers. Additionally, in the case studies the importance of personal network was emphasized, as the family played a major role in all the three market entry and development processes.

The research conducted by Utterback (1974) tells that on average it takes 8 years from idea to final product, but with varieties depending on the industry and size of the firm. In total the process of the innovations covered in this thesis took three years to build a refrigerator out of clay, seven years to make a sanitary napkin and the machine to make the napkins, and four years to build a milking machine.

Doing research for a local frugal innovation is risky. During the development phase, the local frugal innovations have no source of income despite investing time and money to the innovation. Additionally, the innovator is investing his limited resources without guarantees that the outcome will generate enough profit to sustain a living. Additionally, while researching and prototyping, there is little time for other activities which are giving immediate returns.

6.2.4 Linear Model of Innovation for local frugal innovations

The innovation process for local frugal innovations is modified through the situational factors of the emerging country context, the particular needs of the customers and by definition the requirement of creating a novelty product. The Linear Model of Innovation presented in chapter 2.2 has certain assumptions which are in conflict with the innovation process of local frugal innovations introduced in this chapter.

The first assumption, that innovations are generated through highly educated engineers and scientists, does not apply to local frugal innovations. Grassroots innovators have often not

completed any education such as Mansukhbhai and Muruganantham nor are they scientists such as Gowda, who works as a school teacher in a rural village.

Proposition 1: Educational background is not a determining factor for the success of local frugal innovations.

Instead of science as a source of knowledge, previous experience of the innovator is utilized as a source of know-how and methods used in the research phase. Family background, the living environment and the free time activities of the local frugal innovator are contributing to his skill set. Additionally, the innovator's problem-solving skills are also developing throughout the process. The innovations studied are technological, and the innovators have gained the skills to work with machines through previous work experience and curiosity.

Proposition 2: Local frugal innovators learn by doing throughout the innovation process and utilize their previous experience for the benefit of the innovation.

The third assumption from innovation literature is, that the idea for an innovation arises from science or from the public agenda. However, the idea for a local frugal innovation comes from close to the innovator as a desire to find a solution to a problem he sees in the normal everyday life within his community. Mansukhbhai created a solution to a problem within his village, Muruganantham for his wife and Gowda started with the milking machine to create a solution for himself.

Proposition 3: The idea for local frugal innovations come from a problem visible in the everyday life of the innovator.

The assumption that working on innovations takes place in a department devoted to research and development is not true for local frugal innovations. Within that department employees have access to the skills, resources and financial means required for the innovation process. Mansukhbhai had bought a piece of land for his factory, but Muruganantham did research at home to the unpleasant surprise of his mother, who did not want to be part of her son's activities. Likewise, Gowda worked on the milking machine in his own farm. Furthermore, the innovators conduct the research alone and on their own means.

Proposition 4: Local frugal innovators operate alone, on their own means and with a constrained budget.

6.3 Challenges

The challenges and uncertainties listed by Utterback (1974) can also be applied for frugal innovations. The local frugal innovators' main constraint is the lack of resources and inability to act, but contrary to Utterback (1974), the challenge is not only within the firm but also in relation to the external environment. For instance the lack of electricity is not an internal constraint but rather an issue of lacking infrastructure for reasons external to the innovator. Internal challenges come from the limited skills of the innovator, and time is needed to learn.

Likewise, Utterback (1974) argues that the organizational structure and the multiple facets of a firm's strategy are a hindrance for innovation. However, in the case of an individual innovator at the grassroots level the operating logic differs from a firm. As the cases show, the innovator has all strings in his hand from idea till diffusion of the innovation. A clear strategy is missing since the idea has emerged and is becomes clear only after the first success of the product.

Local frugal innovators successfully overcome the challenges. External challenges are seen as opportunities rather than barriers. For instance the lack of infrastructure is seen as an inspiration. Local frugal innovations are therefore often device operating without electricity. Through experimenting, learning by doing, and trial and error, the innovator learns important skills throughout the process.

According to Utterback (1974) uncertainties faced by a firm are coming from the external environment and the internal operations. In the cases studied in this thesis, the internal operations during the development process were mostly in the hand of one individual. For this reason, all time and effort went into the innovation itself and little resources were invested in understanding the wider external environment, when it comes to for instance regulations on intellectual property or distribution.

Furthermore, the innovation was not based on information from the market but on the innovators personal need. The local frugal innovator does not conduct market research, the size of the market or the location. The understanding of the external environment outside his village is limited, and mostly not regarded as very important.

6.4 NIF & GIAN as main partners

The assistance and support the innovators received, albeit after years of conducted research, was of great help for the overall success of the innovation. Comparing Mitticool, which received support from several research, education and corporate institutions, with the sanitary napkin machine and the milking machine, which were granted mainly only financial support shows the role assistance has on business development related activities. Mansukhbhai, the innovator of Mitticool, also greatly benefited from the help and support of his mentor.

In the cases studied, both NIF and GIAN played an important role in the development and diffusion of the innovation. Through NIF, the innovators had access to recognition, awareness among the communities and access to knowledge. GIAN provided practical assistance in design, packaging and testing. The functions of these two organizations are based on the philosophy of the Honey Bee Network. It emphasizes the ability poor people have in knowledge creation. People living at the bottom of the economic pyramid deserve being recognized with name when referring to their contributions. Finally, if a third party benefits from the knowledge produced by others, it should be channelled back to the community owning the knowledge. (Honey Bee Network, 2015).

As NIF focuses on the knowledge development, it has assisted in filing 700 patent applications (National Innovation Foundation, 2014a). NIF has a wide variety of other activities (National Innovation Foundation, 2014c), which are for instance documentation of innovations and traditional knowledge through field work. The innovations or traditional knowledge are then added to the national database of innovations. Once the innovators are found, they usually need assistance when it comes to design and the final touch of product development. NIF also helps in the process of commercialization and social diffusion of knowledge which can be shared without violating intellectual property rights. (National Innovation Foundation, 2014c).

Additionally funding is needed. The Micro Venture Innovation Fund (MVIF), which also the three cases benefited from, is the mechanism of NIF for that. The innovators have little financial means to invest in the innovation, loans are not an option due to the requirement of a collateral and for venture capitalists the funds needed are too small to be interesting. Operating since 2004, MVIF is a dedicated risk fund for commercialisation of technological innovations generated at the grassroots level. The fund is unique since to receive funding, no collateral or guarantor is needed. Additionally, MVIF invests in high risk projects and the application

process is fast and simple. Assistance in funding also includes support of a mentoring team. (National Innovation Foundation, 2014b).

Another activity by NIF are the annual awards for grassroots innovators and traditional knowledge holders, which have greatly benefited the three cases covered in the thesis. The awards are given to the innovators by the president of India. The eighth time awards were given was in March 2008, when 41 individuals from six different districts across India were received recognition. (National Innovation Foundation, 2015).

GIAN is an incubator, helping to translate a grassroots innovation into a scalable business, with as the ultimate goal poverty alleviation and sustainable development. The organization facilitates the help through channelling modern science, marketing knowledge and funding for the benefit of innovators at the grassroots level. Moreover, it aims to influence policy making to be more inclusive for knowledge creation also at the grassroots level. (Grassroots Innovation Augmentation Network West, 2008a).

The incubation path includes the strong network of NIF and GIAN. Once the Honey Bee Network has identified and documented an innovation, NIF and GIAN take care of the assessment of the innovation and technology. This is followed by competitive benchmarking by GIAN summer interns or volunteers, after which the project is either closed or considered for more consultation of GIAN and the MVIF fund by NIF. The consultation includes Intellectual Property Right protection, the creation of a business plan and mass marketing. Prototypes and the development of production are still responsibilities of the innovator. (Grassroots Innovation Augmentation Network North, 2015).

7 Conclusion

The aim of this thesis was to understand how frugal innovations emerge in India. Furthermore, the main research interest was the innovation process and attention was paid to the ideation, development and commercialization of the innovation. The data material was from the grassroots context, which was the reason to establish a new concept of local frugal innovations to emphasize the situational context of innovators with very limited resources. As there has not been extensive academic research on frugal innovations yet, nor on frugal innovations from the grassroots, the expected outcome of the thesis was to build theory to understand the process.

This chapter presents a framework explaining local frugal innovations and the innovation process related to them. This is followed with a list of practical implications. Due to the research method and data material used, also the limitations of the study need to be pointed out. Finally, the chapter is finished with suggestions for future research stimulating to further investigate the uniqueness of local frugal innovations.

7.1 Framework of Local Frugal Innovations

Local frugal innovations are simple products to solve pressing problems. The innovator of such products lives in a resource constraint environment, does not necessarily have formal education and acts alone throughout the process. Thus the people acting as innovator has a very similar profile than the target market. The product is affordable for its users, who previously did not have access to a product innovated due to financial or infrastructural constraints. Likewise, the daily tasks which were previously done manually are eased with the presence of the machine suitable for the local context.

The innovations emerge from a simple process (Table 4). It starts with a serious need. The idea to start working to develop a solution may come from experiencing the need personally or through influence from an outsider. For this reason the network is important already in the idea generation phase. The innovator makes the decision to find a solution himself, and keeps the ownership of the entire process until the end.

The innovation is related to the previous skills of the innovator. The educational background, whether a low level of education or being trained for a certain profession, does not play a major role for the skills necessary to develop the final product. Instead the skills are learned since a

young age through personal experiences and hobbies. For this reason the local frugal innovations tend to be technical solutions and machines since operating a machine does not require a formal education.

Table 4 The framework for Local Frugal Innovations

Idea <ul style="list-style-type: none"> - Serious need - Visible to the innovator - Skills through previous experiences 	Research and development <ul style="list-style-type: none"> - Practical research - Experimenting - Learning while doing 	Market entry <ul style="list-style-type: none"> - First customer - Reputation - Publicity
<p>----- NETWORK -----</p>		
		Final product
Own resources & budget		Support <ul style="list-style-type: none"> - Financial - Design - Intellectual property rights

Before the final product is ready, the innovator has to conduct research and develop prototypes. Research is very practical, as it is finding answers to the questions that arise during the process. As the process is often not started with the aim to develop a product which will be sold on the market, the innovator does not always know in advance what the next steps are. Through experimenting and learning by doing, the innovators struggle through development, arriving eventually at a usable product.

The major part of the research is conducted by the innovator alone. He does not always have excessive financial means but is instead highly motivated to complete the process. The research and development phase can take years, during which the innovator is investing time and money, which is only limitedly available, without certainty that the final product will bring any financial returns.

Feedback is the most important tool when developing prototypes. During the development phase feedback is asked from those who are valued by the innovator as expert and belong to the network. This can be either people with a higher education or representatives of the potential user group.

Finding the first customer is important, firstly because it proves the product has market potential. Secondly, it gives long awaited returns to the innovator. The customer is also important to increase the confidence of the innovator, to show to a wider audience the product works and to initiate peer to peer marketing, which is an important communications channel. This aspect is emphasized when the customer is an expert from the field of the innovation.

The awareness of the product grows also through media publicity as it is a cheap channel with very little effort from the innovator. Winning innovation competitions and national awards helps to get media coverage. Customers usually approach the innovator directly, and in the beginning the distribution and sales happens more on an ad hoc basis. This because the innovator, who has turned into an entrepreneur, needs to orientate to the new role.

Broader support enters the picture only towards the end of the process. Especially assistance with intellectual property rights is important that the innovators do not lose the right to their innovations. For this reason the ownership of the innovation remains in the hand of the innovator. Consequently, he is also able to make decisions regarding the diffusion of the innovation.

The final innovation involves more than the product. Firstly, since local frugal innovators tend to decide to keep the production close to the origin of the innovation and thus generating employment to remote areas. Secondly, since the customer have now access to a product, which previously was too expensive when living on a limited budget, the social benefit is huge. Local frugal innovations can increase the independence of a marginalized group such as farmers living in remote areas or women, and thus also trigger change in society.

7.2 Practical implications

There are three basic implications that can be drawn from this research to practice. Firstly, the incubation path developed by GIAN proves to be successful to leverage the success of an innovator acting alone. Secondly, the innovation awards of NIF are powerful in terms of rewarding, recognizing and spreading the word of the local frugal innovations, which were previously unknown.

Thirdly, financial support for local frugal innovations do not have to be huge. Small amounts of funding will benefit the community of the innovator but also widely outside. It is more important to find the innovators in need of financial assistance early in the process, as that is the moment when funding is the most needed.

A suggestion for corporate practises is to copy the can-do attitude and the passion from the local frugal innovator operating in an extreme environment, which for instance rural India is, to the everyday challenges faced in a Western organization. Attributes characterizing the process local frugal innovations have to go through are for instance not knowing what the challenges are at the beginning yet starting the journey, working hard to overcome obstacles and not forgetting one's values even when it is tempting. Radjou et al. (2012, pp. 160–161) also mention intuition and following one's heart instead of basing decisions on what data suggests.

7.3 Limitations of the study

There is a risk that the case studies in this thesis will be perceived as insubstantial due to the distance to the innovations, the access to data was limited. Elger (2010) explains that case studies are either a deep examination of one particular setting or a broad investigation of also the internal and external context. He continues arguing, that research is a trade-off between the depth and breadth of the study. One strategy to overcome this dilemma, which is also applied to this thesis, is to use different sources which offer a variety of views on the case and thus also different perspectives of depth and breadth to the case. Nevertheless, conducting research is a trade-off between the restrictions by resources, and the deepness and the extensiveness of the finished work. (Elger, 2010).

For this thesis an exploratory study was chosen to initially investigate the innovation process of innovating at the grassroots level. Elger (2010) points out that the value of exploratory studies is in identifying key features of a case and its context. For this reason some aspects may be covered less intensively and the case-studies can then be considered not in-depth enough. As a consequence of the long distance, the source of the data used in this thesis is primarily secondary. However, to avoid a biased view, a one-sided story or missing relevant details, a set of diverse sources is used in the research. As mentioned in Rothbauer (2008), triangulation of

sources is the method to avoid biased interpretations of the data material and helps “to identify, explore, and understand different dimensions of the units of study” (Rothbauer, 2008).

Furthermore, limitations also concern time resources. A final thesis is followed by graduation and entering working life. Currently, the need to be finished with studies is relatively urgent and therefore there is little room to be flexible, but instead it is important to follow the schedule. This is also influencing the distance constraints, as traveling to India was therefore not seen as a realistic option.

Another constraint is related to the researchers understanding of the context in which the innovators live, since it is very particular. It is contrary to the daily life of the researcher and therefore it might be difficult to interpret the context correctly. As an objectivist thesis, the understanding is that reality is built within the context of the knowledge of the researcher, who has lived in India 3 months observing the environment, culture and ways of living. This thesis aims to build an understanding of the Indian context based on research and own experiences, which can then be interpreted as the truth.

Further limitations might arise from the analysis as there is no possibility to ask clarifying questions afterwards. Each step in the process will be documented as analysis notes, and later also described in detail in the thesis. This is to guide the reader by the hand through the process of what has been done before arriving at a given conclusion.

Finally, the thesis covers only three grassroots cases even though there are many more already in India alone. Generalization to all innovations from the local context cannot be directly made. However, the cases chosen are viewed as representational for frugal innovations on the grassroots level, and the issue of generalizability has been considered when choosing the cases. More research would be needed on the innovation process and the innovators as well, to draw a more general picture.

7.4 Suggestions for future research

From the findings and the framework presented certain questions arise, which require additional research to come to a more comprehensive understanding of local frugal innovations. Firstly, it would be interesting to discover what the role of the different components are in

building the success of the innovators. For instance, to what extent has the network of the innovator contributed to developing a product ready for the market from scratch. Additionally, would the research process be faster had the innovator received external support earlier in the process.

The notion of limited financial resources and the absence of external financing is interesting when considering the high quality of the innovation outcome. Thus, future research should also investigate what the role of funds in the research by frugal innovators on the grassroots level is. Would earlier funding mechanisms encourage more innovators to pursue a business locally from the innovation created?

The question whether local frugal innovators should be provided assistance or whether that would destroy the organic emergence of innovations at the grassroots would be worth examining in the future. Possible alternatives are the role of external assistance earlier in the process, providing better access to modern scientific knowledge to rural villages through information technologies and tools for finding local frugal innovations in the need of support earlier.

Related to funding and other assistance is also the notion of entrepreneurship skills. Could the operations of the local frugal innovators be optimized better, if there was available structured training on marketing, accounting and logistics?

Secondly, future research could investigate whether there is a linkage between local frugal innovations in emerging markets and start-ups in the Western countries. This might prove useful since understanding the process of local frugal innovations in the emerging country context, where people make high quality products with very limited resources, could add to the knowledge how to support agile start-ups. Similarly vice-versa, understanding the ecosystem of start-ups might prove useful for countries like India willing to build an ecosystem supportive for frugal innovations.

Likewise, studies in the future should focus on local frugal innovations in another geographical areas such as East African countries, where the mobile banking application M-Pesa originated. This is to understand the similarities and differences between India and other emerging countries.

Finally, in the forthcoming research could focus on discovering the role of personality and characteristics in starting the journey from a resource-scarce environment towards an innovation, and where the intrinsic motivation comes from in moments of desperation. For this a more involving research method should be applied to understand the individual and its act better.

8 References

- BBC. (2014). The Indian sanitary pad revolutionary. From <http://www.bbc.com/news/magazine-26260978> on 9.3.2015.
- Benaquisto, L. (2008). Codes and Coding. In L. Given (Ed)., The SAGE Encyclopedia of Qualitative Research Methods. Thousand oaks, US: SAGE Publications, Inc.
- Bhatti, Y. (2012a). What is Frugal Innovation? Towards a Theory of Frugal Innovation. Retrieved from <http://ssrn.com/abstract=2005910> on 2.3.2015.
- Bhatti, Y. (2012b). What is Frugal, What is Innovation? Towards a Theory of Frugal Innovation. Retrieved from <http://ssrn.com/abstract=2005910> on 2.3.2015.
- Bhatti, Y., & Ventresca, M. (2012). The Emerging Market for Frugal Innovation: Fad, Fashion, or Fit? Retrieved from <http://ssrn.com/abstract=2005983> on 2.3.2015.
- Bhatti, Y., & Ventresca, M. (2013). How Can 'Frugal Innovation' Be Conceptualized, Said Business School Working Paper Series, Oxford. Retrieved from <http://ssrn.com/abstract=2203552> on 2.3.2015.
- Brem, A., & Ivens, B. (2013). Do Frugal and Reverse Innovation Foster Sustainability? Introduction of a Conceptual Framework. Journal of Technology Management for Growing Economies, 4(2), 31–50.
- Chmiliar, L. (2010). Multiple-Case Design. In A. J. Mills, G. Durepos, & E. Wiebe (Eds)., Encyclopedia of Case Study Research . Thousand oaks, US: SAGE Publications, Inc.
- Christensen, C. M. (2003). The innovator's dilemma: The revolutionary book that will change the way you do business. New York: HarperCollins.
- Datt, R., Jha, S. K., Tak, A. & Salaria, N. 2013. Case Studies on attributes of few dairy based innovations developed at the grassroots across India. Indian Journal of Traditional Knowledge. 13 (3), 564-573. Retrieved from <http://nopr.niscair.res.in/handle/123456789/29129> on 31.3.2015.
- Dawson, J. (2010). Thick Description. In A. J. Mills, G. Durepos, & E. Wiebe (Eds)., Encyclopedia of Case Study Research . Thousand oaks, US: SAGE Publications, Inc.
- Economic Times. (2012). Mansukhbhai Prajapati Mitticool Clay Creations brings clay back in fashion. Retrieved from http://articles.economictimes.indiatimes.com/2012-12-03/news/35568762_1_wankaner-fridge-filter on 9.3.2015.
- Eisenhardt, K. M. (1989). Building Theories from Case Study Research. Academy of Management Review, 14(4), 532–550.
- Elger, T. (2010). Limited-Depth Case Study. In A. J. Mills, G. Durepos, & E. Wiebe (Eds)., Encyclopedia of Case Study Research . Thousand oaks, US: SAGE Publications, Inc.

- Eriksson, P., & Kovalainen, A. (2008). *Qualitative methods in business research. Introducing qualitative methods*. Los Angeles, London: SAGE.
- European Commission. (2014). *EU Energy, Transport and GHG Emissions: Trends to 2050. Reference Scenario 2013*. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/trends_to_2050_update_2013.pdf on 4.5.2015.
- George, G., McGahan, A. M., & Prabhu, J. (2012). Innovation for Inclusive Growth: Towards a Theoretical Framework and a Research Agenda. *Journal of Management Studies*, 49(4), 661–683.
- Given, L. M., & Saumure, K. (2008). Trustworthiness. In L. Given (Ed.), *The SAGE Encyclopedia of Qualitative Research Methods*. Thousand oaks, US: SAGE Publications, Inc.
- Godin, B. (2006). The Linear Model of Innovation: The Historical Construction of an Analytical Framework. *Science, Technology & Human Values*, 31(6), 639–667.
- Govindarajan, V., & Trimble, C. (2012). *Reverse Innovation: Create far from home, win everywhere*. Boston, Massachusetts: Harvard Business Review Press.
- Grassroots Innovation Augmentation Network North. (2015). *Incubation*. Retrieved from <http://north.gian.org/incubation> on 5.5.2015.
- Grassroots Innovations Augmentation Network West. (2008a). *Genesis*. Retrieved from http://west.gian.org/about_us.php on 5.5.2015.
- Grassroots Innovations Augmentation Network. (2008b). *Case Study on Mitticool Clay Creation*. Retrieved from http://west.gian.org/case_studies/case-study-on-mitticool.pdf on 20.2.2015.
- Gummeson, E. (2008). Case Study. In R. Thorpe & R. Holt (Eds.), *The SAGE Dictionary of Qualitative Management Research*. London, UK: Sage Publications Ltd.
- Gupta, A. K. (2013). Tapping the Entrepreneurial potential of grassroots innovation. *Stanford Social Innovation Review*, 11(3), 18–20.
- Hang, C.-C., Chen, J., & Subramian, A. M. (2010). Developing Disruptive Products for Emerging Economies: Lessons from Asian Cases. *Research-Technology Management*, 53(4), 21–26.
- Hindustan Times. (2014). Mitticool: Son of the soil keeps things cool with his 'desi gadget'. From <http://www.hindustantimes.com/india-news/mitticool-son-of-the-soil-keeps-things-cool-with-his-desi-gadget/article1-1172621.aspx> on 9.3.2015.

- Bhandari, H. (2011). Business Development Plan of “The Milking Machine”. Retrieved from <https://www.scribd.com/doc/47761696/Final-Report-of-The-Milking-Machine-as-on-24th-june> on 27.4.2015.
- Honey Bee Network. (2015). About Us. Retrieved from http://www.sristi.org/hbnew/aboutus.php#our_members on 6.5.2015.
- Honey Bee Network. 2004. Rewarding the spirit of Innovation, Part II. Honey Bee. 15 (4), 4-9.
- Immelt, J. R., Govindarajan, V., & Trimble, C. (2009). How GE Is Disrupting Itself. Harvard Business Review, 87(10), 56–65.
- India Today. (2008). White beauty. Retrieved from <http://indiatoday.intoday.in/story/White+beauty/1/10452.html> on 22.4.2015.
- INK talk. (2011). Arunachalam Muruganantham. From <http://www.inktalks.com/discover/177/arunachalam-muruganantham-the-first-man-to-wear-a-sanitary-napkin-inktalks> on 9.3.2015.
- Jayaashree Industries. (2010). How profitable is this? From <http://newinventions.in/profit.aspx> on 24.4.2015.
- Ksheera Enterprise. (2015). Home page. Retrieved from <http://www.milkmasterksheera.com/> on 22.4.2015.
- Lim, C., Han, S., & Ito, H. (2013). Capability building through innovation for unserved lower end mega markets. Technovation, 33(12), 391–404.
- MacQuarrie. (2010). Visual Research Method. In A. J. Mills, G. Durepos, & E. Wiebe (Eds.), Encyclopedia of Case Study Research . Thousand oaks, US: SAGE Publications, Inc.
- Menstrual Man. (2012). Director's Statement. Retrieved from <http://www.menstrualman.com/filmmaker/statement/> on 1.4.2015.
- Menstrual Man. (2013). A documentary film by Amit Virmani. Retrieved from <http://www.menstrualman.com> on 24.4.2015.
- Minnpost. (2010). Meet A. Muruganantham, India’s tampon king. Retrieved from <http://www.minnpost.com/global-post/2010/05/meet-muruganantham-indias-tampon-king> on 4.5.2015.
- Mitticool. (2011). About Mitticool Clay Creation. Retrieved from <http://www.mitticool.in/aboutus.php> on 9.3.2015.
- Narasimhalu, A. & Dula, C. (2012). Jayaashree Industries: Revolutionising Sanitary Pad Use in India. Case Study published by Singapore Management University. Accessed directly from the authors.

- National Innovation Foundation. (2014a). About NIF. Retrieved from <http://nif.org.in/aboutnif> on 5.5.2015.
- National Innovation Foundation. (2014b). Business Development and Micro Venture Innovation Fund (BD & MVIF). Retrieved from <http://nif.org.in/bd> on 5.5.2015.
- National Innovation Foundation. (2014c). Our Activities. Retrieved from http://nif.org.in/our_activities on 5.5.2015.
- National Innovation Foundation. (2015). Biennial Awards. Retrieved from http://nif.org.in/eighth_award on 6.5.2015.
- National Innovation Foundation. (2005). Third National Grassroots Technological Innovations and Traditional Knowledge Awards. Retrieved from http://nif.org.in/dwn_files/3rd_Award_Book.pdf on 31.3.2015.
- National Innovation Foundation. (2014). MVIF assistance to the projects sanctioned. Retrieved from http://nif.org.in/sanctioned_projects on 6.5.2015.
- National Innovation Foundation. (2009). National Biennial Grassroots Technological Innovation and Traditional knowledge Awards 2009. Retrieved from http://nif.org.in/dwn_files/5th_Award_Book.pdf on 31.3.2015.
- Outlook India. (2005). Raghava Gowda. Retrieved from <http://www.outlookindia.com/article/Raghava-Gowda/227940> 22.4.2015.
- Permaculture News. (2013). Mitticool lay refrigerator. From <http://permaculturenews.org/2013/01/15/mitticool-clay-refrigerator/> on 9.3.2015.
- Pink, S. (2006). Visual Methods. In V. Jupp (Ed.), The SAGE Dictionary of Social Research Methods. London: SAGE Publications, Ltd.
- Planning Commission. (2013). Twelfth Five Year Plan (2012-2017): Faster, More Inclusive and Sustainable Growth. Retrieved from http://planningcommission.gov.in/plans/planrel/12thplan/pdf/12fyp_vol1.pdf 2.5.2015.
- Prahalad, C. K. (2014). The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profits (Revised and Updated 5th Anniversary Edition): Pearson FT Press.
- Prahalad, C. K., & Hart, S. L. (2002). Fortune at the Bottom of the Pyramid. Strategy+business, (26).
- Prahalad, C. K., & Mashelkar, R. A. (2010). Innovation's Holy Grail. Harvard Business Review, 88(7/8), 132–141.
- Radjou, N., & Prabhu, J. C. (2014). Frugal innovation: How to do more with less (First edition). New York, United States: The Economist.

- Radjou, N., Prabhu, J. C., & Ahuja, S. (2012). *Jugaad innovation: Think frugal, be flexible, generate breakthrough growth* (1st Ed).. San Francisco, CA: Josser-Bass, a Wiley Imprint.
- Rao, B. C. (2013). How disruptive is frugal? *Technology in Society*, 35(1), 65–73.
- Rasmussen, K. B. (2008). General Approaches to Data Quality and Internet-generated Data. In N. Fielding, R. M. Lee, & G. Blank (Eds), *The SAGE Handbook of Online Research Methods* (pp. 79–97). London: SAGE Publications, Ltd.
- Ray, P. K., & Ray, S. (2010). Resource-Constrained Innovation for Emerging Economies: The Case of the Indian Telecommunications Industry. *IEEE Transactions on Engineering Management*, 57(1), 144–156.
- Rogers, E. M. (2003). *Diffusion of innovations* (5th Ed).. New York: Free Press.
- Rothbauer, P. M. (2008). Triangulation. In L. Given (Ed), *The SAGE Encyclopedia of Qualitative Research Methods*. Thousand oaks, US: SAGE Publications, Inc.
- Shrum, W., & Duque. (2008). Film and Video in Qualitative Research. In L. Given (Ed), *The SAGE Encyclopedia of Qualitative Research Methods*. Thousand oaks, US: SAGE Publications, Inc.
- Society for Research and Initiatives for Sustainable Technologies and Institutions. (2012). Final Report. Retrieved from <http://www.sristi.org/cms/griid/IDRC-Final-Report.pdf> on 31.3.2015.
- Society for Research and Initiatives for Sustainable Technologies and Institutions. (2012). Final Report. Retrieved from <http://www.sristi.org/cms/griid/IDRC-Final-Report.pdf> on 31.3.2015.
- Stake, R. E. (2006). *Multiple Case Study Analysis*. New York: Guilford Press.
- Streb, C. K. (2010). Exploratory Case Study. In A. J. Mills, G. Durepos, & E. Wiebe (Eds), *Encyclopedia of Case Study Research*. Thousand oaks, US: SAGE Publications, Inc.
- TED Talk. (2012). How I started a sanitary napkin revolution! From https://www.ted.com/talks/arunachalam_muruganantham_how_i_started_a_sanitary_napkin_revolution?language=en on 9.3.2015.
- TedTalentSearch. (2012). Mansukhbhai Prajapati: Building modern technology -- with clay. Retrieved from https://www.youtube.com/watch?v=ZI_YCKKLc4M on 22.4.2015.
- The New Indian Express. (2013). 'Menstrual Man' made men think, women laugh at DIFF. Retrieved from <http://www.newindianexpress.com/entertainment/hindi/Menstrual-Man-made-men-think-women-laugh-at-DIFF/2013/10/27/article1858657.ece> on 1.4.2015

- The New Indian Express. (2012). The milky way. Retrieved from <http://www.newindianexpress.com/states/karnataka/article186885.ece> on 6.5.2015.
- The Tribune. (2014). Barefoot innovators. Retrieved from <http://www.tribuneindia.com/news/spectrum/barefoot-innovators/13900.html> on 22.4.2015.
- The World Bank. (2015a) Official exchange rate. Retrieved from <http://data.worldbank.org/indicator/PA.NUS.FCRF> on 12.5.2015.
- The World Bank. (2015b). India. Retrieved from <http://data.worldbank.org/country/india> on 1.4.2015.
- Trivedi, Jigna C. (2011). A Study on Micro Venture Capital Finance in India with Special Reference to Gujarat. Chapter 6: Comprehensive case studies funded by GIAN. Retrieved from http://shodhganga.inflibnet.ac.in/bitstream/10603/7330/14/14_chapter%206.pdf on 31.3.2015.
- Utterback, J. M. (1974). Innovation in industry and the diffusion of technology. *Science*, 183(4125), 620–626.
- Van der Boor, Paul, Oliveira, P., & Veloso, F. (2014). Users as innovators in developing countries: The global sources of innovation and diffusion in mobile banking services. *Research Policy*, 43(9), 1594–1607.
- Williamson, P. J. (2010). Cost Innovation: Preparing for a ‘Value-for-Money’ Revolution. *Long Range Planning*, 43(2-3), 343–353.
- World Resources institute & International Finance Corporation. (2007). The Next 4 Billion: Market Size and Business Strategy at the Base of the Pyramid. Retrieved from <http://www.wri.org/publication/next-4-billion> on 1.4.2015.
- Yin, R. K. (2003). *Case Study Research: Design and methods* (Third Edition). Thousand oaks, US: SAGE Publications, Inc.
- Zeschky, M., Widenmayer, B., & Gassmann, O. (2011). Frugal Innovations in Emerging Markets. *Research-Technology Management*, 54(4), 38–45.
- Zeschky, M., Widenmayer, B., & Gassmann, O. (2014). Organising for reverse innovation in Western MNCs: the role of frugal product innovation capabilities. *International Journal of Technology Management*, 64(2/3), 255–275.