

Framework for Environmental Practices in Frugal Innovation

Carolina Marques da Silva Leite

Department of Engineering and Management, Instituto Superior Técnico

Abstract

The current behaviour performed by society is leading towards a severe situation where almost two planets are required to supply the existing resource demand and to absorb all the waste generated. This concerning condition combined with the global economic slowdown and with the increasing pressures placed on companies by customers and governments is reflecting a shift in the market trends. In order to ensure the well-being of future generations, a revolution is needed. Frugal innovation appears as a sustainable revolution that empowers the creation of affordable solutions, products and services while preserving the natural ecosystem and addressing social inclusion. This profitable business strategy satisfies the demand for basic needs but mainly, allows a more sustainable use of natural resources and a reduction of environmental impacts. The frugal innovation literature shows that the environmental pillar of sustainability is being poorly addressed by authors and academics around the world. Thus, in the present work, a great focus is placed on the environmental sustainability of frugal innovation. Circular economy appears as a sustainable solution whose practices can empower environmental sustainability throughout an entire value chain of a product or service. Thus, incorporate circular economy activities into frugal innovation value chain can be an excellent approach to increase the environmental sustainability of frugal innovation value chain. Along these lines, the objective of this work is to develop an integrated framework that supports corporations managing frugal innovations in identifying which practices can be implemented in order to boost the environmental sustainability of their value chain. Based upon a literature review, the knowledge on frugal innovation and circular economy was systematized, in order to derive a collection of circular economy practices and a characterization of the frugal innovation business patterns. The framework results of the triangulation of the information obtained in the literature review and aims at exporting these theoretical findings to the business atmosphere. The results suggest that the collected circular economy practices are relevant to increase the environmental sustainability of frugal innovation value chains and that the framework can be an excellent launching pad to frugal companies start considering environmental issues in their managerial insights.

Keywords: Frugal Innovation, Circular Economy, Framework, Environmental Sustainability

1. Introduction

A significant number of disruptive trends are strongly influencing the future global development and prompting a new path for the world economy. First, the global financial crisis, characterized by a low Gross Domestic Product (GDP) growth rate and a high unemployment rate, is constantly leading to less disposable income (Engel and Sebaut, 2014). In addition, most developed economies have reached a stage where customer needs are almost totally met (Radjou et al., 2015). This led to a situation of global economic slowdown and market stagnation where the unique redemption is a changing atmosphere full of sustainable and innovative practices. As reported by Radjou and Prabhu (2015), “advanced economies have entered an

age of austerity in which the notion of frugal living and consuming is becoming mainstream”. At second place, society is currently consuming 1.6 times more than the planet can replenish (Global Footprint Network, 2016). As noted by Radjou and Prabhu (2015) current rates and predictions argue that by 2030, two planets would be required to supply the needed resources and to absorb all the generated waste. The world is demanding an extreme change since resource scarcity is threatening the viability of businesses. However, this call is not just for people and individuals, but is mainly for companies and organization, who must be more efficient in how they use raw materials (Roland Berger Strategy

Consultants, 2014) so target efficiency and sustainability.

Third, customers, today, are much more cost and environmental conscious and an adaptation is needed to ensure abidance. Regarding the cost, values are shifting towards a sustainable work-life balance and “people are willing to earn less money and adapt their consumption patterns toward low-frills offers” (Engel and Sebaux, 2014). Concerning the environment, “buying patterns are shifting to less wasteful products” (Engel and Sebaux 2014) and customers desire products and services that are less damaging and harmful for the planet. The reason behind these wishes is related to the fact that customers have realised that the planet’s health affects their own, and consequently become more environmental conscious.

Although these disruptive trends are leading the world economy to an austere situation, it is essential to reverse this path by retaining the positive aspects of this changing conditions. In fact, the current atmosphere creates a favourable circumstance of increasing opportunities for sustainability-based developments (United Nations, 2015). Frugal innovation appears as an exceptionally valuable and reliable solution since frugal products and services are developed in a sustainable manner (Rocca, 2016), i.e., minimising the use of resources and environmental impacts while enhancing social value. Frugal innovations are increasingly being adopted by more companies and forecasts reveal a remarkable growth in the future. In fact, Roland Berger Strategy Consultants (2014) highlighted that firms that already have frugal products in their portfolio will double their efforts on this area of development, accounting 22% of the sales and generating 20% of the overall profit (Rocca, 2016).

This paper aims at purposing a comprehensive framework for environmental sustainability in frugal innovation through the analysis of circular economy practices. The framework aims to be a pro-active and structured tool that helps decision-makers in improving companies’ environmental performance of the entire frugal innovation value-chain.

The paper is organized as follows. Section 2 summarizes the extensive literature review performed to gather relevant information on the frugal innovation and circular economy topics. Then, in Section 3 the methodology is described. Section 4 shows results and discussion of the employed methodology. Finally, in Section 5 the major conclusions are discussed.

2. Literature Review

2.1. Frugal Innovation

The literal meaning of the word “frugal” is defined as “simple and plain and costing little” (Oxford Dictionaries, 2017) and it is “characterized by reflecting economy in the use of resources” (Merriam Webster Dictionary, 2017). During the recent years, frugal innovation has been calling the attention of practitioners and scholars (Bhatti and Ventresca, 2013). This new field of research was comprehensively studied by many researchers who defined differently frugal innovations (Lehner and Gausemeier, 2016). The adopted definition for the present work rests on the most complete approach established by Rocca in 2016: *“Frugal innovations are products, services, processes and business models that target underserved customers of low-mid market segments with high-quality solutions at affordable prices. They are developed in a sustainable and cost-effective manner that minimise the use of resources, materials and capital in the entire value chain, while enhancing social value.”*

The other definitions were also analysed and two fundamental aspects can be highlighted: i) Despite most conceptualizations of frugal innovation do not inherently consider sustainability aspects (Brem and Wolfram, 2014), this is a hot topic, which is recently gaining special attention. The theoretical roots of frugal innovation can be explained through the intersection between social, economic and environmental concerns, ii) The frequency of keywords such as “affordable”, “resource-constrained”, “good-enough” and “low-cost” strengthen the importance of these attributes in frugal innovation.

Frugal innovation’s core characteristics are: incorporate robust components to face of the variation in operating environment and harsh conditions (Kumar and Puranam, 2011); develop affordable products accessible to all social strata including less affluent segments (Hamacher, 2014); focus on functionality to create intuitive and minimalist products that actually solve problems (Radjou and Prabhu, 2015); leverage local support and resources (Soni, 2013); reduce the time-to-market to ensure usefulness over perfection (Roland Berger Strategy Consultants, 2015); target volume-demand markets to boost mega scale production (Kumar and Puranam, 2011); employ resource efficient and environmental-friendly impact practices to develop sustainable innovation (Rosca et al., 2016).

Some researchers restrict frugal innovations to emerging and newly industrializing countries (George et al, 2012; Eager et al., 2011) while others argue that frugal solutions are also demanded by consumers from developed economies (Bhatti and Ventresca, 2013;

Hossain, 2016). The truth is that both markets are increasingly demanding frugal innovations and will broadly have higher levels of disposable income and sustainability. These conditions enabled a favourable situation for frugal innovation companies who must explore the potentialities of both emerging and developed markets.

The future success of frugal innovation in the global market not only depends on the target market but also depends on the fields of activity where frugal products can be employed. Literature shown that frugal innovation is extremely broad and new developments can be invented in all sectors from healthcare and energy until finance and education.

The last step in this literature review on frugal innovation was precisely to: 1) identify the evolution of the content of frugal innovation documents; 2) understand which subjects have major potential to be explored in further investigations. The procedure followed have started with a rigorous selection of papers from the Internet through online publishers and databases and after the first data treatment, only 40 articles were selected for further investigation. This analysis returned a key conclusion: 12 documents have considered sustainability as an important support of frugal innovation but none have focused on the environmental sustainability pillar. Thus, this subject can definitely be considered a potential source of increasing findings and opportunities and for that reason, it was selected for further investigation.

2.2. Circular Economy

The industrial economy, throughout its evolution and diversification, has barely moved beyond one fundamental representative established in the beginning of industrialization: The Linear Economy (Ellen MacArthur Foundation, 2012). The premise of this model relies on the 'take-make-dispose' pattern where "companies extract materials, apply energy to them to manufacture a product, and sell de product to an end consumer, who then discards it when it no longer works or no longer server the user's purpose" (Ellen MacArthur Foundation, 2012). However, the incessant stimulation of this throwaway-mindset and excessive consumption brought several concerns and depletion problems (Lieder and Rashid, 2016).

Therefore, in order to eliminate or reduce most of the severe problems originated by this straight economy, a new approach seems to appear as the consummated solution: the Circular Economy. This restorative and regenerative economy (Ellen MacArthur Foundation, 2015) is the key element that enables the leap from consuming and discarding products to using and reusing

them to the maximum extent possible (Ellen MacArthur Foundation, 2012). The inclusion of this reusing-mindset is exactly what differs circular economy from the other two approaches. Circular economy envisions a "future where nothing is wasted; a future where every "waste" becomes an asset; a future where all products at the end of their primary use are recovered and either reused, remanufactured or recycled for multiples generations" (Jawahir and Bradley, 2016). In fact, this new economic model is the one capable to decouple global economic development and prosperity from finite resource consumption (Ellen MacArthur Foundation, 2015), i.e., society can continue to consume goods and services but not depending on the extraction of virgin resources (Sauvé et al., 2016).

As the concept of circular economy reflects parts of this vast number of theories and is grounded in the study of non-linear systems, particularly living ones (Ellen MacArthur Foundation, 2012), there is a significant number of elements that perform an important role in the circular economy concept development. Ellen MacArthur Foundation (2015) incorporated some of these influences on its study and have created three main principles that they believe to be the fundamentals of circular economy definition: 1) Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows; 2) Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles; 3) Foster system effectiveness by revealing and designing out negative externalities.

A successful implementation of circular economy fully depends on the actions and behaviours that are being adopted. There are several activities that can be followed by circular economy strategies and each of these activities is composed by a panoply of specific practices that should be chased in order to achieve certain goals. There are five main broad activities that definitely need to be followed in all circular economy strategies: 1) eco-design; 2) green procurement; 3) cleaner production; 4) sustained lifespan and 5) recovery economy.

These six activities were assessed through a literature review on the circular economy subject, where the main focus was to understand what have been addressed by the authors and researchers. Many of the circular economy studies that have been published worldwide (Ghisellini et al., 2016), beyond the theoretical basis, also reflect the insights of the circular economy strategies that have been implemented across continents and economies. Thus, the activities addressed in the circular economy literature, although its undeniable theoretical

character, are also sustained by practical applications (McKinsey & Company, 2016). The state-of-the-art of circular economy is constituted by a considerable number of documents (case studies, reviews, scientific reports, etc) (Ghisellini et al., 2016) that are strongly committed in building a solid basis for the concept of a circular economy. Inside this vast list of studies, eight documents published in the time interval between 2012 and 2017 were selected: Ellen MacArthur Foundation (2012), Su et al. (2013), Ghisellini et al. (2016), Sauvé et al. (2016), Lieder and Rashid (2016), Elia et al. (2017), Geissdoerfer et al (2017) and Winans et al (2017). This selection was performed having three important aspects in mind: 1) the selected documents were published after 2010 in order to achieve a greater proximity with current reality; 2) the two documents that were released in 2012 and 2013, i.e., Ellen MacArthur Foundation (2012) and Su et. al (2013), were selected due their high frequency of appearance in the novel literature; 3) the remaining six articles were published between 2016 and 2017, and selected due to its recent and updated information.

Applying the circular economy activities into an already established value chain could be an excellent way to incorporate environmental sustainability into value chain activities as well as increase its future competitiveness and prosperity. Thus, the framework developed in the next chapters, will precisely answer the following research question: Which circular economy practices can be implemented by frugal innovation corporations, under a specific market context, in order boost the environmental sustainability of their value chains?

3. Methodology

The research methodology employed is a qualitative research analysis (Glaser and Strauss, 1967; Flick, 2009; Dillon, 2012) based on five investigation strategies: Literature Review, Case Study Analysis, Grounded Theory and Focus Group (Adams and Schvaneveldt, 1991; Bell, 2005; Saunders, 2009). This multi-methodology approach (Mingers and Gill, 1997) was developed and employed along the building procedure of the final framework (Framework for Environmental Practices in Frugal Innovation) which is composed by two core frameworks: the Environmental Practices Framework and the Market Characterization Framework. Figure 1 presents a flow-diagram of the methodologies that were employed in order to accomplish the final framework.

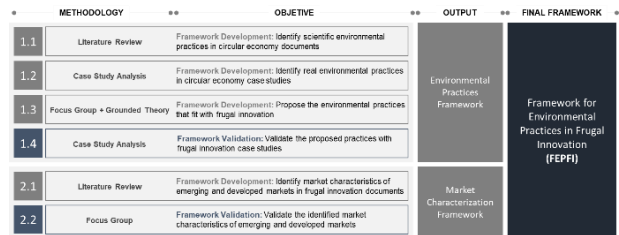


Figure 1: Framework Research Methodology

In order to develop the Environmental Practices Framework: 1) a literature review was performed to identify scientific environmental practice in circular economy documents; 2) a case study analysis was performed to identify real environmental practices in circular economy case studies and 3) a grounded theory and focus group were performed to propose the environmental practices that fit with frugal innovation. After the development, the Environmental Practices Framework was then validated through a case study analysis whose objective was to validate the proposed practices with frugal innovation case studies.

In order to develop the Market Characterization Framework, a literature review was performed to identify market characteristics of emerging and developed markets in frugal innovation documents. The framework was then validated using the focus group methodology.

At the end, both frameworks were integrated to generate a methodology of creating frugal products with circular economy practices. This integration was performed to highlight that the application and implementation of the selected environmental practices in frugal innovation value chains depend on the markets characteristics where frugal products are being developed (From) and targeted (To).

3.1. Environmental Practices Framework Methodology

3.1.1. Framework Development Methodology

Literature Review

At first place, a literature review was proceeded in order to identify the scientific environmental practices that researchers and academics are continuously mentioning in their circular economy studies. This literature review was performed on the circular economy subject since the goal was precisely to retain the environmental practices that are contributing and supporting the theoretical insights of circular economy articles. The literature review was the methodology used since a robust emphasis on high-quality original research rather than on interpretations of the findings, enables a direct assurance that the results have a sustained basis of support and accuracy (Fink, 1998). The following eight documents published in the time interval between 2012 and 2017 were selected to be once again reviewed: Ellen

MacArthur Foundation (2012), Su et al. (2013), Ghisellini et al. (2016), Sauvé et al. (2016), Lieder and Rashid (2016), Elia et al. (2017), Geissdoerfer et al. (2017) and Winans et al. (2017).

Case Study Analysis

The second research methodology followed in the framework development was a case study analysis (Yin, 2003). Analogously to the literature review, the final purpose of this procedure was to gather the real circular economy practices that are being implemented by organizations in a practical context. According to Eisenhardt (1989), the case study methodology approach is especially appropriate in new topic areas and can be used to accomplish three specific aims: to provide description (Kidder, 1982), test theory (Pinfield, 1986), or generate theory (Gersick, 1988). In this particular case, the case study analysis was performed to achieve all three dimensions. First, information regarding the environmental practices was collected to obtain a clear description of each one. Second, the case study analysis was performed after the literature review in order to test the theoretical findings in practice. Finally, some of the case study findings were innovative and not mentioned in the literature and this novel information generated new sources of theory.

There are several companies that are best in class in the application of circular economy practices and those companies were selected to be analysed in this case study analysis. In order to ensure that the companies selected were actually implementing circular economy practices, the 39 case studies addressed on the Ellen MacArthur Foundation website were considered. Their updated information and enormous reputation on the circular economy subject sustained this choice.

These 39 case studies cover different sectors of research, namely: Built Environment, Chemistry, Cross Sector, Electronic and Electrical Equipment, Fabrics Apparel Carpets Textiles, Fast Moving Consumer Goods, Information and Technology and Machinery and Automotive. Thus, analysing these case studies seem to be the most adequate not only due to the reliability of the information but also due to the wide scope that they encompass.

Focus Group and Grounded Theory

The last methodologies employed were the focus group (Khan and Manderson, 1992) and grounded theory (Dillon, 2012).

The focus group methodology is a tool used to understand perceptions, interpretations and opinions from a particular issue (Khan and Manderson, 1992). These interactive group discussions are seen as a direct data collection method (Stewart and Shamdasani, 2015).

As reported by Winke (2017), “analyzing focus group data is as diverse and multidimensional as investigating any type of qualitative data” and the grounded theory is an appropriate methodology to analyse that information (Charmaz, 2014). The grounded theory appears as an acknowledged form of qualitative research that involves using multiple stages of data collection and enables the refinement and interrelationship of information (Dillon, 2012). Usually, this methodology is employed in the second stage of the exploratory research precisely to systematize the ideas and empower the theory building and to derive of principles from data (Strauss and Corbin, 1998). The purpose of using the grounded theory is to develop a procedure that identifies general patterns and regularities between the information and combines the data in different categories.

After conducting a literature review and a case study analysis on circular economy, a significant amount of information was collected but the environmental practices were not systematized, triangulated and categorized. Thus, in order to propose the environmental practices that fit with frugal innovation: 1) a focus product group was performed to determine which practices found in the literature and case studies fit with frugal innovation (according to its definition, core characteristics and markets insights) and 2) the grounded theory was used to group those practices in the five main activities of a circular economy value chain: Eco-Design, Green Procurement, Cleaner Production, Sustained Lifespan and Recovery Economy. The proposed output was the following: 9 environmental practices were assigned to the Eco-Design; 4 environmental practices were assigned to the Green Procurement; 6 environmental practices were assigned to the Cleaner Production; 5 environmental practices were assigned to the Sustained Lifespan; 4 environmental practices were assigned to the Recovery Economy (figure 2).

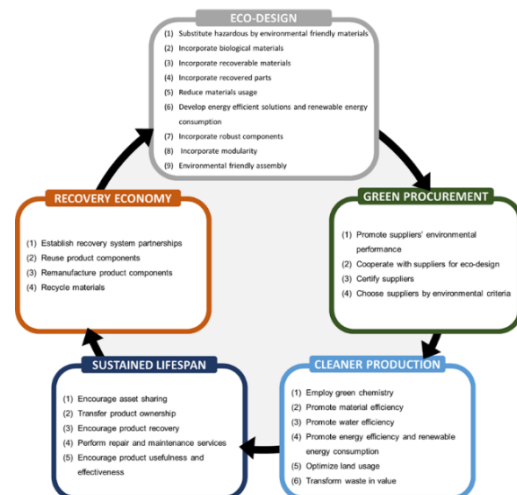


Figure 2: Environmental Practices Framework

3.1.2. Framework Validation Methodology Case Study Analysis

A case study analysis was performed aiming to: 1) identify and collect the frugal innovation products referred in the frugal innovation documents; 2) retrieve information from those documents and other sources available online regarding these frugal innovation products and its respective value chains.

It should be noted that the first goal of identifying the frugal products was performed to facilitate the second process of gathering information from the documents and other available sources. The information was then consolidated and analysed in order to find which frugal product value chains are implementing the proposed environmental practices.

Regarding the scientific documents, the collection of the papers and other relevant documents on frugal innovation was already performed on the literature review where 28 out of 41 frugal innovation documents encompassed frugal innovation case studies. In fact, the content of those 28 documents was meticulously analysed and the frugal innovation case studies referred by the authors was listed.

The findings were astonishing, and the research returned a complete list of frugal innovation products that altogether encompasses 213 frugal case studies. In this process, a broad interpretation of the documents and a peripheral treatment of the findings was performed to narrow the boundaries of the investigation and to identify only the solutions that were considered frugal innovations by the authors. This methodology aimed at identifying all the frugal products retrieving from frugal innovation documents but an exhaustive evaluation of the products to contest the suitability degree with frugal criteria was not performed. This methodology assumed that: 1) all collected products were cheaper than available alternatives in the market; 2) all collected products tackle social or environmental issues; 3) higher the number of citations a product have, higher its probability of being a frugal innovation product.

The results of the literature review enable drawing some important conclusions: 1) The selection of documents to review revealed to be accurate since by analysing 28 documents, 213 cases of frugal innovation were found from the literature; 2) The most frequently cited products of frugal innovation are Tata Nano, GE's ECG machine, GE's Ultrasound machine, Aravind Eye Care; ChotuKool; Tata Swach, Mitticool; M-Pesa, Jaipur Foot and Tata Ace.

3.2. Market Characterization Framework Methodology 3.2.1. Framework Development Methodology

Literature Review

The major purpose of this methodology was to review frugal innovation articles and other documents available online specialized in market characterizations in order to collect and define the characteristics that major influence frugal innovation. In the literature review on frugal innovation, 18 out of 40 frugal innovation documents encompassed the Market subject (see column M – Market). Thus, those documents, following presented, were selected to be further explored in the present investigation. During the literature review, it was noticed that markets in different maturity stages entail different characteristics. The infrastructure and resource availability, the political and governmental issues, the commitment and coordination among supply chain stakeholders, the technological advances are some examples of market conditions that have different performances depending on the market maturity stage. Besides, consumers also have different future perspectives and wishes and are very strict to their own buying patterns and once again those characteristics are intrinsically dependent on the maturity stage of the market.

Thus, the Market Characterization Framework provides a distinction between emerging and developed markets was performed and encompasses the market condition' characteristics and the consumers' characteristics.

3.2.2. Framework Validation Methodology

Focus Group

The major purpose of this methodology was to validate the identified market characteristics of emerging and developed markets. A focus group methodology was conducted in order to gather perceptions, interpretations and opinions regarding the proposed market conditions' characteristics and consumers' characteristics.

4. Results and Discussion

4.1.1. Environmental Practices Framework

The proposed practices exposed on the framework were validated through the information regarding the frugal products retrieved from scientific documents and other sources of knowledge available online (e.g. frugal products webpages). The illustrative validation table for the eco-design activity is following presented.

Table 1: Eco-design Practices Validation

Eco-Design Practices	Validating Frugal Solution	Motive of Validation
Substitute hazardous by environmental friendly materials	M-KOPA	M-KOPA, a rent-to-own solar lighting solution, allows Kenyans to have access to clean electricity in their rural homes (Rocca, 2016). M-KOPA market alternatives use paraffin, a hydrocarbon liquid combustible derived from petroleum. This unsustainable practice led the M-KOPA Solar company to develop a solar energy product and, so far, the replacement of this hazardous material has reduced 380K tonnes of CO2 (based upon 1.3 tonnes of CO2 reduced per M-KOPA Solar system over 4 years) (XXX).
	ModRoof	ModRoof is a modular roofing system for rural areas and informal city settlements in the developing world (Rocca, 2016). The main component of the roofing systems is panels that are custom manufactured from agriculture waste. These panels, developed in-house, in India, incorporate biological materials such as natural fibres and binders made by plants, animals and geological processes (XXX).
Incorporate biological materials	Dacia Logan	Dacia Logan, launched by Renault in 2004 priced at 5,000 euros, is an affordable, robust and well-designed car (Radjou and Prabhu, 2015; Hossain, 2016). The car reflects a simple architecture that needs 50% fewer parts than a high-end- Renault vehicle and 95% of its components are recyclable (Rocca, 2016, XXX).
Incorporate recoverable materials	Liter of Light	Liter of Light is a global and grassroots movement whose volunteers teach marginalized communities how to use recycled plastic bottles and locally sourced materials to illuminate their homes, businesses, and streets (Numminen and Lund, 2016, XXX). Energy poverty keeps more than a % of the world's population in darkness and in order to strike this trend more than 350,00 Liter of Light recovered bottles were installed in more than 15 countries (XXX).
	MAC 400	MAC 400, an electrocardiogram device from the product portfolio of the multinational General Electric (Tiwari et al., 2014), was launched in India's domestic market, with a focus on core functionalities and reduced to the essence (Rocca, 2016). Portability and miniaturization is highly important in India due to poor transportation and space constraints (Kumar and Purnam, 2012). Thus, GE aimed at developing a product that fits the market needs (Soydan, 2009) and have created a product that only weights 1.3 kg (Tiwari et al., 2014).
Reduce materials usage	Mitticool	Mitticool, a refrigerator made out of clay, embody a simple technology that functions on the cooling effect of water evaporation (Numminen and Lund, 2016). The product, that costs almost 60 % less than a comparable fridge in the same market (Weyrauch and Herstatt, 2016), embraces energy frugality since it entails zero electricity consumption (Hossain, 2016).
Develop energy efficient solutions and renewable energy consumption	ToughStuff	ToughStuff, as the name suggests, is a solar panel charging system designed for harsh physical environment. The design and materials contribute to the system ability to operate in extreme environments and create a physical protection against weather impacts (e.g. rain, heat, insect ingress). According to Basu et al. (2013), "a thin sheet of amorphous silicon that uses sunlight to generate electricity makes the product both nearly indestructible".
Incorporate robust materials	ChotuKool	ChotuKool is a portable, small-sized and compact fridge suitable for countries where erratic power supply and frequent power outages are common. In fact, the refrigerator keeps its contents cool for up to 3 hours without power connection. To minimise costs, Godrej, an Indian conglomerate, reduced the number of parts from 200 to only 20 modular parts (Khan and Halder, 2015; Hossain et al., 2016).
	Tata Swachh	Tata Swachh, a water purification system, was originally developed to poor households in India. The goal was to provide accessible and safe drinking water and to reduce the incidence of water borne diseases. In order to succeed in this target market, Tata Group developed this water filter based upon two important elements: easy of assembly and easy of maintenance. It encourages and facilitates filter replacement (Basu et al., 2013).

Based on the validation process performed, some concluding topics must be highlighted.

1. Frugal innovation supply chains are environmental sustainable since they are implementing circular economy environmental practices.
2. The environmental practices proposed on the framework revealed to be accurate since they demonstrate to be feasible and suitable to the frugal innovation context.
3. There are products and respective value chains that validate more than one environmental practice, i.e., that are implementing several environmental practices referred in the tables. However, the inclusion of different examples was prioritized to extend the scope of the research and to diversification the range of products. The products that are able to validate more than one environmental practice correspond to: 1) products that have higher number of citations on the frugal innovation documents and consequently have more information associated; 2) products that were developed by multinationals whose online available data sources and websites are full of relevant information.
4. From the information retrieved and analysed in the validation process, a large amount of data is able to validate the eco-design environmental practices. This happens since frugal innovation is a product-based innovation in which product functionality, performance and simplicity entail a huge relevance.

Thus, data regarding product development features and characteristics are the ones most mentioned by scholars and practitioners in frugal innovation documents and frequently available on online sources.

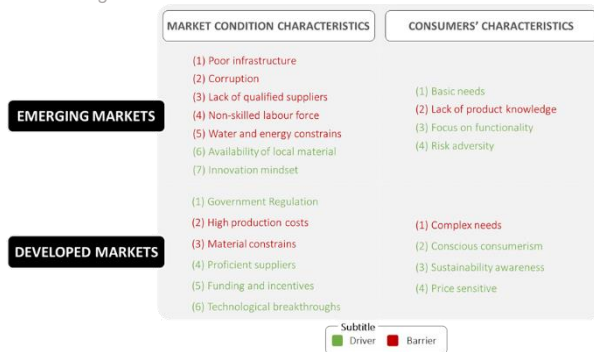
5. There are three environmental practices that have more than two potential validating case studies:
 - Incorporate biological materials (ModRoof, Husk Power, Agricultural Biomass Gasifier, Ghana Bamboo Bikes and Bamboo Microscope);
 - Develop energy efficient solutions and energy consumption (Mitticool, ChotuKool, Vortex ATMs and Micromax).
 - Incorporate robust materials: ToughStuff, Nokia 1100 and MAC 400.
6. The environmental practice 'transfer product ownership' does not have a validating product. Although, M-KOPA is a rent-to-own solar lighting solution that offer a very attractive leasing scheme, when the consumers complete their periodic payments, they become the owner and responsible of the product. Thus, M-KOPA is not able to validate the practice. The reason behind the difficulty of finding a product to validate the 'transfer product ownership' practice is inherent to the concept of frugal innovation. In fact, frugal innovation includes affordable products that are accessible to a large number of consumers. The low cost and high-volume characteristics limit the ability of companies in owning a huge amount of low priced products. Besides, the poor transportation and distribution infrastructures combined with the lack of a recovery system in emerging markets difficult the ability of companies to recover their products.

4.1.2. Market Characterization Framework

The market characterization framework (figure 3) appropriately exposes the main characteristics that better describe both, developed and emerging markets, under the frugal innovation context. These characteristics are schematized in the matrix' columns and addresses two relevant themes. The market conditions refer all the characteristics that are not linked to consumers such as resource constrains or availability, political and economic insights, etc. The consumers' characteristics encompasses the features that reflect consumers' wishes, mindset and buying patterns.

These characteristics retrieved from the frugal innovation literature were also analysed according to the frugal innovation context where the definition and core characteristics of frugal products and value chains were studied. The result of this analysis shown that some characteristics can be considered drivers since they enable and boost the spread of frugal products and can be considered barriers when they threaten the success and viability of frugal innovation within the market. Figure 3 presents the market characterization framework with the drivers in green colour and the barriers in red colour.

Figure 3: Market Characterization Framework



In general, it can be highlighted that the market conditions' characteristics in developed markets tend to be provide more efficient operational flows and less structural constraints when implementing frugal innovation value chains (the barriers are more significant in emerging markets). The consumers' characteristics in emerging markets tend to better fit with the core characteristics of frugal products (simplicity, functionality, ergonomics, etc) (the barriers are more significant in developed markets).

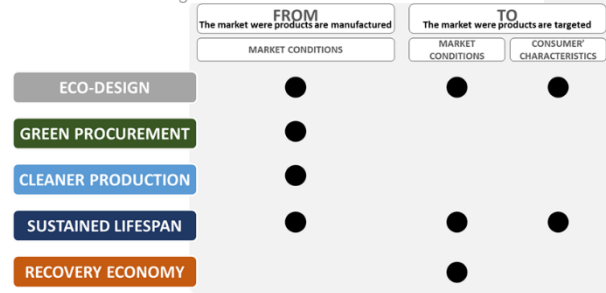
4.1.3. Framework for Environmental Practices in Frugal Innovation (FEPFI)

The FEPFI results of the integration between the Environmental Practices Framework and the Market Characterization Framework. FEPFI was created to provide a generic methodology on what market characteristics should be taken into account when a company or entrepreneur aims at incorporating environmental practices in frugal innovation value chains. This final framework was developed due to the fact that the applicability of environmental practices is highly dependent on the market characteristics and in order to be well succeeded on incorporating the circular economy practices proposed those market characteristics must be considered.

The following indicative table, presented on figure 4, provides a systematization that allow frugal companies to understand which quadrants of characteristics (shown on the Market Characterization Framework) must be taken into account when they desire to invest in

implementing an eco-design, green procurement, cleaner production, sustained lifespan or recovery economy practices.

Figure 4: FEPFI Indicative table



FEPFI Quick Reference Guide

In order to demonstrate the connection between the indicative table, the Environmental Practices Framework and the Market Characterization Framework, an illustrative presentation will be following conducted. Table 2 presents the FEPFI by displaying its methodological steps using a specific example as reference (a company aiming at incorporate eco-design practices that produces in a developed market and targets emerging consumers).

Table 2: FEPFI Quick Reference Guide

Step	Illustration
Step 1: Select the environmental practices from the circular economy value chain activities that compose the Environmental Practices Framework.	Diagram showing selection of practices: Eco-Design, Green Procurement, Cleaner Production, Sustained Lifespan, Recovery Economy. Includes a list of 10 eco-design practices.
Step 2: Retrieve from the indicative matrix the type of characteristics that must be considered to implement the selected environmental practices (see the black balls).	Diagram showing the indicative matrix with black balls indicating relevant characteristics for the selected practices.
Step 3: Identify the market where product is being manufactured and the market where product is being targeted.	Diagram showing the transition from Developed Markets (FROM) to Emerging Markets (TO).
Step 4: Select the quadrants presented on the Market Characterization Framework according to the black balls of the indicative matrix.	Diagram showing the Market Characterization Framework with highlighted quadrants for Emerging and Developed Markets.
Output: In order to incorporate eco-design practices, a company that manufactures in developed markets and aims at satisfying consumers in emerging markets must take into account the characteristics highlighted in step 4.	Diagram showing the final FEPFI matrix with highlighted characteristics for the specific scenario.

Framework Implications for Theory

Implications The majority of studies have recognized frugal innovations as environmental sustainable solutions (Basu et al., 2013; Bound and Thornton, 2012; Rocca, 2016). However, none document has deeply addressed the environmental pillar with the deserved attention. Thus, as referred in the Problem Statement (see Section 1.2) this study aimed to bridge the existence gap in the literature through an in-depth investigation

on the link between frugal innovation and environmental sustainability, placing a strong focus on analysing frugal innovation value chains.

The Framework for Environmental Practices in Frugal Innovation aimed at demonstrating this connection. And in fact, through the framework, a major implication for frugal innovation state-of-the-art can be emphasized: frugal innovation value chains are environmental sustainable.

By using frugal innovation real case studies to demonstrate the link between frugal innovation and environmental sustainability, the reliability and accuracy of the work performed in this master thesis is guaranteed.

Through the present study, and using the main outcomes of the developed frameworks as a first step, other frugal innovation' researchers can develop relevant future works that can positively contribute to the connection between frugal innovation and environmental sustainability. In fact, the FEPFI reinforces the potential of connecting both concepts in the academic world.

Framework Implications for Practice

The Framework for Environmental Practices in Frugal Innovation (FEPFI) incorporates the all-encompassing practices and success factors to achieve an environmental sustainable frugal innovation value chain. Thus, with regards to managerial practice, the present research may be useful for frugal innovators who can benefit from this knowledge. Companies and entrepreneurs that are currently developing frugal products or aims at investing in frugal innovation in the future, have in FEPFI a set of practices that undeniable boost the environmental sustainability of frugal innovation value chains. These practices, collected from successful circular economy case studies, undertake positive outcomes for the environment and reflect irrefutable benefits in terms of economic viability.

The environmental benefits are inherent to the considered practices and the majority is transversal to the five main activities accounted. By implementing these practices, relevant environmental positive outcomes are obtained such as reduction of waste and CO₂ emission, inclusion of the 3R actions, resource efficiency, renewable energy usage and asset sharing.

In opposite to the environmental benefits, the economic viability of implementing a certain practice is not implicit and it must be analysed in greater prevalence since its impact on economic savings is fully dependent on the market and on the frugal solution that is being developed. However, some of the collected practices directly reflect positive economic benefits.

Other economic benefits can be attained by implementing some of the selected practices. However, a case dependent analysis must be performed in a specific level rather than maintaining the holistic perspective that represents the goal of the present study. The framework constitutes a generic tool that should be adapted to specific applications. The FEPFI was built in independent modular blocks precisely to facilitate this tailoring process (e.g. in some frugal innovation value chains, a certain activity or environmental practice might not be applied).

Companies and entrepreneurs by analysing the content of the present study, have also access to a glossary that explains the meaning of each practice incorporated in the framework. This glossary includes the definition and relevance of each practice and contains a practical example of a case study that enables to perceive how each environmental practice is being implemented in the real context. The existence of a practical example is crucial to guarantee that the message is clearly transmitted, and it is essential to boost creativity and indulge inspiration.

By analysing the FEPFI, frugal innovators have access to both relevant characteristics and this enable them to adjust their environmental sustainable business model strategies. In fact, the ability of implementing a certain environmental practice can be dependent on the market condition where frugal products are being developed and targeted. Moreover, the impact of a certain practice can also be strictly related to the consumers' behaviours, needs and wishes. As the framework extol these attributes, companies and entrepreneurs can take advantage of this knowledge to achieve sustainable competitive positions.

Concluding, the FEPFI aims to be a pro-active and structured tool that helps decision-makers in improving companies' environmental performance of the entire frugal innovation value-chain. Its goal is to offer guidelines to choose the most appropriate environmental strategies and ensure that they fit to the specific frugal innovation characteristics. Besides, the FEPFI boosts systemic thinking by suggesting the best environmental practices for all activities along the solution's life-cycle. The framework was created in order to be consulted by: 1) corporations that are already developing frugal products or 2) companies that have no prior experience in frugal innovation but aims at developing frugal solutions. The former target has the opportunity to evaluate their environmental practices and to assess if new actions are able to be implemented under their specific market context. The latter target can examine the environmental practices as a checklist to

prioritize objectives and anticipate constraints and decide the actions that should be implemented according to their market context.

5. Conclusions

Future global development is strongly influenced by the disruptive trends that are prompting a new path for world economy. Society is consuming more than the planet can replenish, projections estimate a population increase that will trigger a surge of demand for natural resources, the global warming is negatively affecting the overall supply of agriculture products and fresh water and customers are increasingly desiring less wasteful products. All these elements are boosting a new mindset, a mindset rested on environmental sustainability.

These environmental concerns are pushing governments and organizations in adopting strategic solutions that do not compromise planet wellbeing. The idea behind the development of the present work was exactly to provide a feasible solution that rests on “creating environmental sustainable products in an environmental sustainable way”.

After a comprehension investigation, it was perceived that combining frugal innovation and circular economy, both environmental sustainable approaches, would be an excellent and valuable way to accomplish the abovementioned guideline. The idea is to develop frugal products and services by applying circular economy practices into the frugal innovation value chains.

The analysis performed confirmed that combining frugal innovation with circular economy is a feasible solution since frugal products (through its core characteristics) represent the type of product input needed to guarantee a sustained circular economy strategy implementation. Circular economy practices can be applied and incorporated into frugal innovation value chains and this merge would definitely increase the environmental sustainability of frugal value chains and would create a worthwhile long-term condition for world economy.

Thus, in the present master thesis the Framework for Environmental Practices in Frugal Innovation (FEPFI) was created to propose the environmental practices that fit with frugal innovation particular context and boost the environmental sustainability of frugal innovation supply chains. Moreover, the framework presents the frugal market characteristics of emerging and developed markets that should be studied and analysed when those environmental practices will be implemented.

6. References

Adams, G. and Schvaneveldt, J. (1991). *Understanding Research Methods*, New York.
 Bell, K. (2005). *Doing your Research Project* (4th edn), Buckingham, Open University Press.
 Bhatti, Y. and Ventresca, M. (2013). How Can “Frugal Innovation” Be Conceptualized?.

Brem, A. and Wolfram, P. (2014). Research and Development from the bottom up - Introduction of Terminologies for New Product Development in Emerging Markets. *Journal of Innovation and Entrepreneurship*, 3(1): 1-22.
 Charmaz, K. (2014). *Constructing grounded theory*. Los Angeles: Sage.
 Dillon D. R. (2012). Grounded Theory and Qualitative Research. *The Encyclopaedia of Applied Linguistics*.
 Eager, R., van Oene, F., Boulton, C., Roos, D., and Dekeyser, C. (2011). The Future of Innovation Management: The Next 10 Years. *Prism*, 1 (1): 21-37.
 Eisenhardt K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, 14, 4, 532-550.
 Elia, V., Gnoni, M. and Tornese, F. (2017). Measuring circular economy strategies through index methods: A critical analysis. *Journal of Cleaner Production*. 142(1): 2741–2751.
 Ellen MacArthur Foundation. (2012). *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*. Report. Available at: <https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf>. Accessed February 2017.
 Ellen MacArthur Foundation. (2015). *Delivering the Circular Economy: a Toolkit for Policymakers*. Report. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthur-Foundation_PolicymakerToolkit.pdf. Accessed February 2017.
 Engel, K. and Sebax, E. (2014). *Capturing the Power of Frugal Innovation*. Report.
 Fink, Arlene. *Conducting Research Literature Reviews: From the Internet to Paper*. 2nd ed. Thousand Oaks, CA: Sage, 2005;
 Flick, U. (2009). *An Introduction to Qualitative Research*, SAGE Publications Ltd, London, UK.
 Geissdoerfer, M., Savaget, P., Bocken, N. and Hultink, E. (2017). The Circular Economy – a new sustainability paradigm?, *Journal of Cleaner Production*. 143(2): 757–768.
 George, G., McGahan, A. and Prabhu, J. (2012). Innovation for Inclusive Growth: Towards a Theoretical Framework and a Research Agenda. *Journal of Management Studies*.
 Gersick, C. (1988) Time and transition in work teams: Toward a new model of group development. *Academy of Management Journal*, 31, 9-41.
 Ghisellini, P., Cialani, C. and Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114(2): 11-32.
 Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Chicago: Aldine Publishing Company.
 Global Footprint Network (2017). *Ecological Footprint*. Report. Available at <http://www.footprintnetwork.org/our-work/ecological-footprint/#worldfootprint>. Accessed March 2017.
 Hamacher, S. (2014). *Exploring the Frugal Innovation Process: An Empirical Study of a New Emerging Market Phenomenon*. Master Thesis. *Copenhagen Business School*.
 Hossain, M. (2016). *Frugal Innovation: A Systematic Literature Review*. Working Paper.
 Jawahir, I. S. and Bradley, R. (2016). Technological Elements of Circular Economy and the Principles of 6R-Based Closed-loop Material Flow in Sustainable Manufacturing. *Procedia CIRP*, 40: 103-108.
 Kahn, M. E., & Manderson, L. (1992). Focus groups in tropical diseases research. *Health Policy and Planning*, 7(1), 56e66.
 Kidder, T. (1982) *Soul of a new machine*. New York: Avon.
 Kumar, N. and Puranam, P. (2011). *Inside India: The emerging innovation challenge to west*, 1-208. *Harvard Business School Press*.
 Lehner, A. and Gausemeier, J. (2016). A Pattern-Based Approach to the Development of Frugal Innovations. *Technology Innovation Management Review*, 6(3): 13-21.
 Lieder, M. and Rashid, A. (2016). Towards circular economy implementation: a comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, 115(3): 36–51.
 McKinsey & Company (2016). *The circular economy: Moving from theory to practice*. Report.
 Merriam Webster Dictionary. (2017). Available at: <https://www.merriam-webster.com/dictionary/frugal>. Accessed January 2017.
 Mingers, J., e Gill, A. (1997). *Multimethodology: Towards Theory and Practice and Mixing and Matching Methodologies*. New York: Wiley.
 Oxford Dictionaries. (2017). Available at: <https://en.oxforddictionaries.com/definition/frugal>. Accessed January 2017.
 Pinfield, L. (1986) A field evaluation of perspectives on organizational decision making. *Administrative Science Quarterly*, 31, 365-388.
 Radjou, N. and Prabhu, J. (2015). Frugal Innovation: How to Do Better With Less, 1-256, *The Economist*.
 Rocca, F. (2016). *Supply Chain Management for Frugal Innovation Product*. Master Thesis. *Instituto Superior Técnico*.
 Roland Berger Strategy Consultants. (2014). *Simple, Simpler, Best: Frugal innovation in the engineered products and high-tech industry*. Report.
 Rosca, E., Arnold, M. and Bendul, J. (2016). Business models for sustainable innovation – an empirical analysis of frugal products and services. *Journal of Cleaner Production*, 1–13.
 Saunders, M. N. K., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students* (5th ed.). Harlow, United Kingdom: FT Prentice Hall.
 Sauv e, S., Bernard, S. and Sloan, P. (2016). Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. *Environmental Development*, 17(1): 48–56.
 Soni, P. (2013). The nature of frugal innovations: A conceptual framework. Conference Paper.
 Stewart, D. W., & Shamdasani, P. N. (2015). *Focus Groups: Theory and practice* (3rd ed.). Thousand Oaks, CA: Sage Publications.
 Su, B., Heshmati, A., Geng, Y. and Yu, X. (2013). A review of the circular economy in China: Moving from rhetoric to implementation. *Journal of Cleaner Production*. 42(3): 215–227.
 United Nations (2015). *Population 2030: Demographic challenges and opportunities for sustainable development planning*.
 Winans, K., Kendall, A. and Deng, H. (2017). The history and current applications of the circular economy concept. *Renewable and Sustainable Energy Reviews*. 68(9): 825–833.
 Winke, P. (2017). Using focus groups to investigate study abroad theories and practice. *System*. 71(9): 73-83.
 Yin, R. K. (2003). *Case Study Research, Design and Methods* (3rd ed). Newbury Park: Sage Publications

