Framework for Environmental Practices in Frugal Innovation

Carolina Marques da Silva Leite

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Supervisor: Prof. Ana Isabel Cerqueira de Sousa Gouveia Carvalho

Examination Committee

Chairperson: Prof. Ana Sofia Mascarenhas Proença Parente da Costa

Supervisor: Prof. Ana Isabel Cerqueira de Sousa Gouveia Carvalho

Member of the Committee: Prof. Fernanda Maria Ramos da Cruz Margarido

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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 definitely empower environmental sustainability throughout an entire value chain of a product or service. Thus, incorporate circular economy activities into frugal innovation value chain can definitely 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 market. 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 definitely 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

Resumo

O comportamento atual da sociedade leva-nos a um panorama ambiental extremamente severo onde são precisos praticamente dois planetas para fornecer a procura de recursos existente e absorver todo o desperdício produzido. O panorama atual conjugado com o abrandamento da economia mundial e com o aumento das pressões feitas pelos consumidores e governos às empresas leva a uma mudança nas tendências do mercado. Para assegurar a continuidade e o bom funcionamento de futuras gerações, impõe-se uma revolução.

O conceito de inovação frugal apresenta-se como a revolução sustentável que fomenta o desenvolvimento de produtos e serviços em consonância com a preservação do ecossistema natural e das necessidades sociais. Esta estratégia de mercado rentável, por um lado satisfaz as necessidades básicas da procura mas, mais importante, possibilita a utilização de forma mais sustentável dos recursos naturais de forma a diminuir os impactos ambientais.

A literatura existente evidencia que os pilares da sustentabilidade ambiental têm sido pouco investigados e relacionados pelos autores e académicos no mundo. Para contrariar esta tendência, o presente trabalho centra-se na sustentabilidade ambiental da inovação frugal.

A economia circular surge como uma solução sustentável cuja a sua aplicação proporciona desenvolver práticas ambientalmente sustentáveis ao longo de toda a cadeia de valor de um produto ou serviço. Incorporar os princípios da economia circular na cadeia de valor frugal é sem dúvida a estratégia ideal para aumentar a sustentabilidade ambiental da cadeia de valor da inovação frugal.

De acordo com as ideias acima descritas, o objetivo do presente trabalho consiste em desenvolver um modelo integrado que, por um lado suporte as organizações na gestão das inovações frugal e, por outro, permita identificar as melhores práticas com vista a desenvolver uma cadeia de valor frugal mais sustentável ambientalmente.

Com base na revisão de literatura e com o objetivo de recolher as práticas da economia circular e de caracterizar o mercado da inovação frugal, todo o conhecimento existente acerca da inovação frugal e da economia circular foi sistematizado. O modelo resulta da triangulação da informação obtida durante a revisão da literatura e pretende transportar o conhecimento teórico para a o mercado real. Os resultados apontam/sugerem que as práticas da economia circular recolhidas desempenham um papel fundamental no desenvolvimento da sustentabilidade ambiental das cadeias de valor da inovação frugal e que o modelo pode ser utilizado como rampa de lançamento para que as empresas frugal comecem a considerar as questões ambientais no seu dia a dia.

Palavras-chave: Inovação Frugal, Economia Circular, Modelo, Sustentabilidade Ambiental

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Glossary

ATM: Automated Teller Machine

GDP: Gross Domestic Product

NGO: Non-Governmental Organizations

BoP: Bottom of the Pyramid

C: Conceptualization

FE: Frugal Examples

SC: Similar Concepts

M: Market

BM: Business Model

SCM: Supply Chain Management

SG: Sustainability in General

ES: Environmental Sustainability

UK: United Kingdom

DNA: Deoxyribonucleic Acid´

FEPFI: Framework for Environmental Practices in Frugal Innovation

1. Introduction

1.1. Background and Context

A significant number of disruptive trends are strongly influencing the future global development and prompting a new path for the world economy. Four trends must be formally described in order to characterize the current atmosphere but mainly to understand the severity of the situation in which the planet earth is inserted.

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 (Radjou et al., 2012; Engel and Sebaux, 2014). In addition, most developed economies have reached a stage where customer needs are almost totally met (Radjou et al., 2012). Both, the existence of less money to spend and the saturation of the consumer market, create 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”. To face the increasing global competition, multinational corporations have to be ‘global all-rounders’ (Zeschky et al., 2014) and need to create a business strategy with an effective collaboration network with different innovators (Rocca, 2016)

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 Prahbu (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. As a consequence, it is crucial to adopt living styles that allows the regeneration and assimilation of earth’s ecosystem (Rosca et al. 2016). 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, and intrinsically related to the previous trend, the exponential growth of world population projected to increase to 9 billion by 2050 (Ellen MacArthur Foundation, 2012), will trigger a surge of demand for natural resources (Lieder and Rashid, 2016). “While about two billion people continue to subsist in basic agrarian conditions or worse, three billion are expected to join the ranks of middle-class consumers by 2030.” (Ellen MacArthur Foundation, 2012). Thus, even the most conservative projections suggest that, over the next decade, the demand for oil, coal, iron and other natural resources will increase by at least a third, with about 90% of that intensification coming from growth in emerging markets (Ellen MacArthur Foundation, 2012). Additionally, the global warming and the variations in regional climates over time will strongly affect the overall supply of agriculture products and fresh water implying supply constraints that would likely drive up prices and volatility (Ellen MacArthur Foundation, 2012).

Forth, 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). Customers experienced financial hardships in USA and in several European countries and this might have pushed them to become more cost conscious (Soni, 2013), seeking more value for less money (Rocca, 2016). 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. For example, 61% of EU citizens are concern with the fact that pollution is damaging their well-being and according to World Health Organization, air pollution caused one in eight deaths worldwide in 2012 (Radjou and Prabhu, 2015).

Although these four main 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 (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 (Roland Berger Consultants, 2014; Rocca, 2016).

1.2. Problem Statement

Many authors have developed noteworthy frugal innovation studies where they clearly focused on addressing the conceptualization of the term by contributing to the definition and core characteristics of frugal innovation. Besides the conceptual matter, many studies have referred several frugal products case studies to support their theoretical contributions and to demonstrate that frugal innovation has an undeniable potential to be transposed to the real context and practical atmosphere. When addressing this real-world approach, some researchers focused on understanding the key market characteristics that enable the spread of frugal products and on perceiving the bottleneck features that can compromise the success of frugal innovation.

In addition to these theoretical insights, the majority of the studies have recognized frugal innovations as environmental sustainable solutions (Basu et al., 2013). In fact, as reported by Rocca (2016), the environmental dimension is implicit in frugal innovation since many frugal products' features reflect the immediate needs of combating resource scarcity, of extending product durability and of claiming the focus on simplicity.

Rao (2013) defended that a core characteristic of a frugal innovation is engineering simplicity in a way that the use of raw materials and other resources are minimized to enable lower manufacturing costs. Bound and Thornton (2012) highlighted that product simplifications through design transformations could lead to considerable energy savings (e.g. an ATM with a minor size and simplified design dropped

the power consumption by 80% when compared with a standard unit). Rocca (2016) reinforced that frugal techniques boost modular products whose components can be easily repaired and replaced and therefore, the products' effective life can be extended and the waste production decreased (Sharma and Iyer, 2012).

Although the existence of the previous examples that confirm that frugal innovation researchers have referred some key principles of environmental sustainability, none document have deeply addressed the environmental pillar with the deserved attention. Besides, environmental sustainability encompasses much more than reducing resource usage, focusing on simplicity, boosting robustness and extending durability. Environmental sustainability must be perceived and evaluated through the all value chain of a product and the impact on the main value chain activities must be accounted.

Thus, this study aims to bridge the existence gap in the literature through an in-depth investigation on the link between frugal innovation and environmental sustainability. Circular economy can definitely enhance the environmental sustainability of frugal products as well as bring newer and useful techniques to frugal innovation value chains. Therefore, combining the frugal innovation and circular economy represent the key element to achieve an environmental sustainable value creation.

At the end of the present work, the following research question must be answered: Which circular economy practices can be implemented by frugal innovation corporations in order boost the environmental sustainability of their value chains? Which markets characteristics should be considered to implement these proposed environmental practices?

1.3. Purpose and Goals

This work aims at purposing a comprehensive framework for environmental sustainability in frugal innovation through the analysis of circular economy practices. In order to perform this goal, other intermediate objectives were addressed and the master dissertation has four major contributions: 1) a comprehensive literature review on frugal innovation and circular economy in order to perceive the theoretical and practical insights of both topics in order to establish a solid basis for the creation of the framework; 2) a collection of circular economy practices that can be a major strength to boost the environmental sustainability of frugal innovation value chains 3) a characterization of frugal innovation business patterns according to their market context 4) a proposal of a new framework, which classifies the collected circular economy practices according to the business pattern and respective context under study.

1.4. Methodology of the Master Dissertation

The following research methodology is composed by the under mentioned five different stages. This methodology was employed in the present master dissertation (see figure 1).

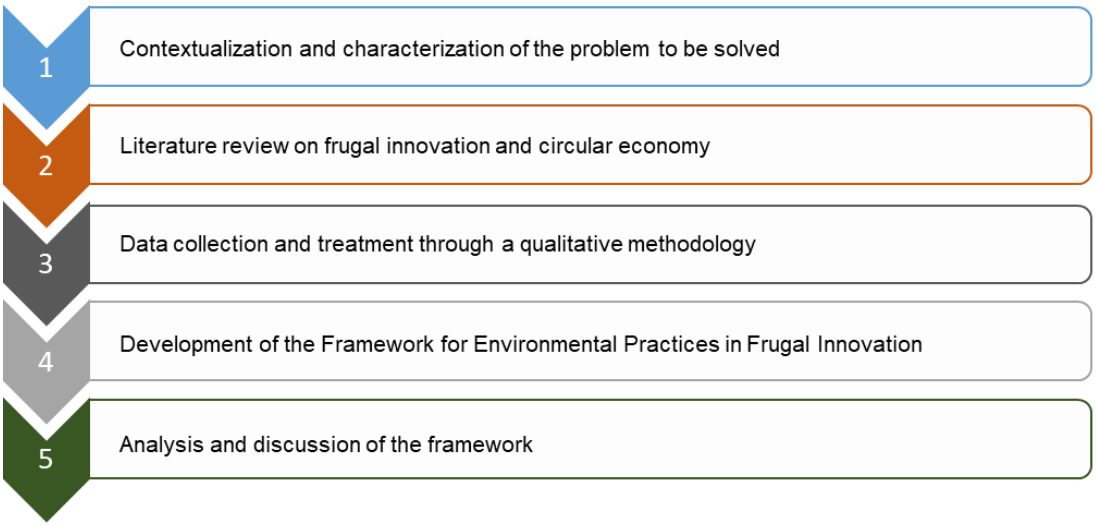


Figure 1: Master dissertation methodology phases

The **first** step includes the contextualization and characterization of the problem to be solved. The two different researched topics, frugal innovation and circular economy, are introduced as well as the motivation to study them.

The **second** level is composed by a comprehensive literature review concerning frugal innovation and circular economy. All the relevant documents will be analysed and the collected information will be organized and compiled into a more attractive and solid approach in order to facilitate the development of future works.

On the **third** stage, the collection and treatment of data is performed. The goal is to conduct a qualitative methodology in order to collect circular economy practices and to characterize the frugal innovation markets.

The **fourth** stage aims at establishing the framework for environmental practices in frugal innovation. The goal is to propose the environmental practices that fit with frugal innovation and to indicate which market condition' characteristics and consumer's characteristics should be taken into account when implementing those practices.

Finally, the **fifth** phase summarizes and discusses the results. At this point, conclusions about the environmental sustainability of frugal innovation value chains must be developed as well as the main implications and benefits of the framework in theory and practice.

1.5. Master Dissertation Structure

The present master dissertation is composed by seven major chapters:

The first chapter describes the background and context of the problem under study. It also presents the purpose and goals of the work as well as the structure of the document.

The second chapter provides a literature review on Frugal Innovation and Circular Economy. In the former, the theoretical and practical thoughts were analysed in order to understand the evolution of frugal innovation definition, the core characteristics of the frugal products and the market potential in developed and emerging countries. It was also performed a state-of-the-art review where the content of frugal innovation documents was analysed. In the latter, the theoretical and practical understandings of circular economy were investigated in order to comprehend the fundamentals of its three main principles. A state-of-the-art review was also presented in order to assess which activities are crucial in a circular economy strategy.

The third chapter describes the methodology developed and employed in the building procedure of the final framework which is composed by two core frameworks: the Environmental Practices Framework and the Market Characterization Framework.

In the fourth chapter, the Environmental Practices Framework was described, and the circular economy practices were validated.

In the fifth chapter, the Market Characterization Framework was developed and the characteristics in emerging and developed markets were explained.

The sixth chapter presents the Framework for Environmental Practices in Frugal Innovation which results from the integration of the Environmental Practices Framework and the Market Characterization Framework. Moreover, this chapter explains the scope of the Framework for Environmental Practices in Frugal Innovation (FEPFI) and the methodology to create frugal products with environmental practices.

Finally, in the last chapter, the main conclusions of the master thesis are presented as well as further considerations for developing future works.

2. State of the Art

This chapter starts to present the theoretical and practical topics of interest to address the relevant knowledge about frugal innovation (Section 2.1). In particular, the most relevant established definitions and its evolution over time, the core characteristics and the market characterization. Furthermore, a comprehensive and thorough literature review was also conducted mainly to understand which subjects have major potential to be explored in further investigations. Then, in the section 2.2, presents the theoretical and practical topics of interest to address the relevant knowledge about circular economy. In particular, the evolution of industrial economy from linear to circular economy, a broadly conceptualization of the topic where the three main principles and 6R's actions were addressed and at the end of this subchapter, a literature review was conducted to understand which circular economy activities must be explores in further investigations. Finally, the last section (Section 2.3) sums up the evidences acquired along the research as well as subsequent implications and conclusions.

2.1. Frugal Innovation – The Environmental Sustainable Innovation

2.1.1. Definition

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). According to the Oxford Dictionaries, the first use of the term dated the mid of the 16th century. However, the combined expression "frugal innovation" was only established in the article "First Break All the Rules – The Charms of Frugal Innovation" published in The Economist, in 2010. In this article, frugal innovations were identified as though and easy to use products, stripped down to their bare essentials. The Economist (2010) also emphasized that is crucial to "take the needs of poor consumers as a starting point".

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). To address a global and generic understanding of the term, the definition proposed by the pioneer article published on The Economist (2010) was established as the starting point, and from then on, other scholars added new specifications and additional information. The goal of this section was to obtain a conceptualized sequence from the first appearance of the term until the present year.

In 2010, frugal innovation was defined as the act of "redesigning products and processes to cut out unnecessary costs" (The Economist, 2010) and as the ability to "do more with less for more people" (Prahlad and Mashelkar, 2010). In addition, Hang et al. (2010) considered that frugal products have the potential to be disruptive.

In the following year, Zeschky et al. (2011) highlighted three important aspects of frugal products: to be good-enough (Soni, 2013; Roland Berger, 2014), to be affordable (Bhatti, 2012; Anderson and Markides, 2012; Brem and Wolfram 2014) and to be able to meet the need of resource-constrained consumers

(Tiwari and Herstatt 2012; Roland Berger, 2014; Rosca et al., 2016). This conceptualization of frugal products leads to a new management philosophy which was aware of the importance to integrate also the specific needs (Gupta, 2011) of those individuals with a lower income (Ernst and Young Strategy Consultants, 2011). For Moore (2011) frugal innovation "focus on core features and eliminate unessential ones" while achieving significantly lower costs (George et al., 2012; Ramamurti, 2012; Soni, 2013) and maintaining high quality (George et al., 2012; Tiwari and Herstatt, 2012; Radjou and Prabhu, 2015).

In order to complement these past definitions, Bhatti (2012) introduced the necessity of redefining business models and reconfiguring value chains (Brem and Wolfram 2014) in a "scalable and sustainable manner". It should be noted that frugal innovations are sustainable when they achieve socio-economic, institutional and environmental requirements (Anderson and Markides, 2012). In the same year, while some researches defined the goal of frugal innovation as reducing the cost of ownership (Tiwari and Herstatt, 2012), others highlighted the importance of reaching hitherto unserved consumers (den Ouden 2012; Soni, 2013).

In 2013, Basu et al. (2013) add to previous definitions that frugal products and services are able to solve sustainability challenges (Cunha et al. 2013) and Bhatti and Ventresca (2013) emphasize that "frugal innovation is a label that captures a range of heterogeneous activities which cut across different sectors".

Believing that past definitions do not retain the true essence of frugal innovation, Rosca et al. (2016) conclude that these new source of innovation "is an inclusive approach that maximizes value for customers, shareholders, and society" but, most of all, is able to create significantly social value (Radjou and Prabhu, 2015).

The definitions previously mentioned present different perspectives in the application areas of the construct (Lehner and Gausemeier, 2016). As reported by Brem and Wolfram (2014) some authors only consider products (Gupta, 2011; Kingsnorth et al., 2011; Zeschky et al., 2011), while others assign the process perspective (Woodward, 2011). Bound and Thornton (2012) and Basu (2013) add services and a substantial number of researchers declare that frugal innovation also encompasses business models (George et al., 2012; Bathi and Ventresca, 2013). The most extensive and broad definition is used by Rocca (2016): "frugal innovations are products, services, processes and business models".

Figure 2 summarizes the evolution of frugal innovation definition along these years.

After this analysis, 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.

The adopted definition for this project rely on the most complete approach that was established by Francesco 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."

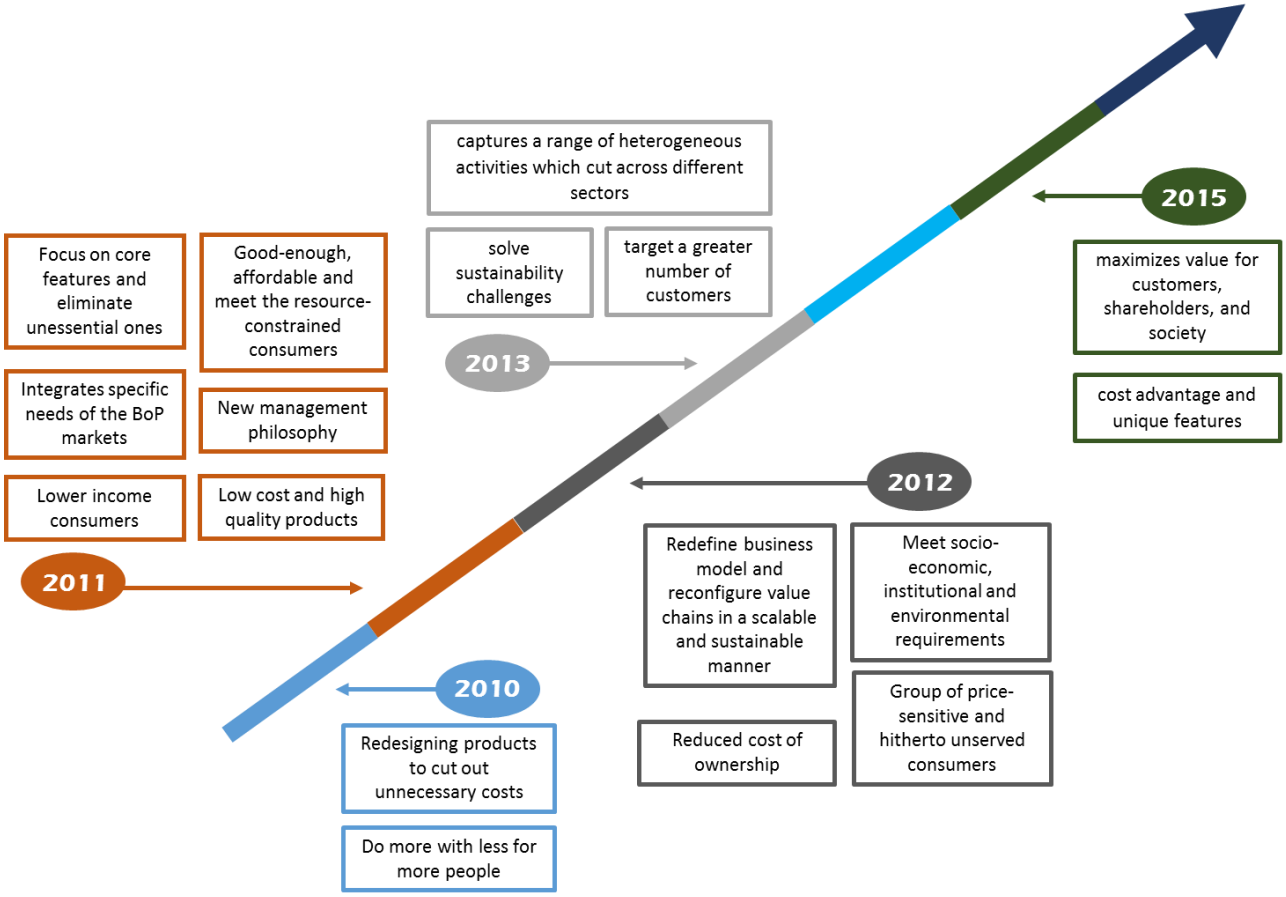


Figure 2: Evolution of frugal innovation definition

2.1.2. Core Characteristics

Some authors have listed some characteristics (Roland Berger Strategy Consultants, 2015; Angot and Plé, 2015), defining features (Radjou and Prabhu, 2015), core competences (Kumar and Puranam, 2011) and attributes (Siemens Strategy, 2013) of frugal innovation to accomplish a wider understanding approach of the term. Since Arnold and Barth (2012) believe that sustainable innovations are creations that provide an essential progress concerning social, economic and ecological aspects, placing these main characteristics in their corresponding area of the Triple Bottom Line is perfect to assess their impact (Figure 3).

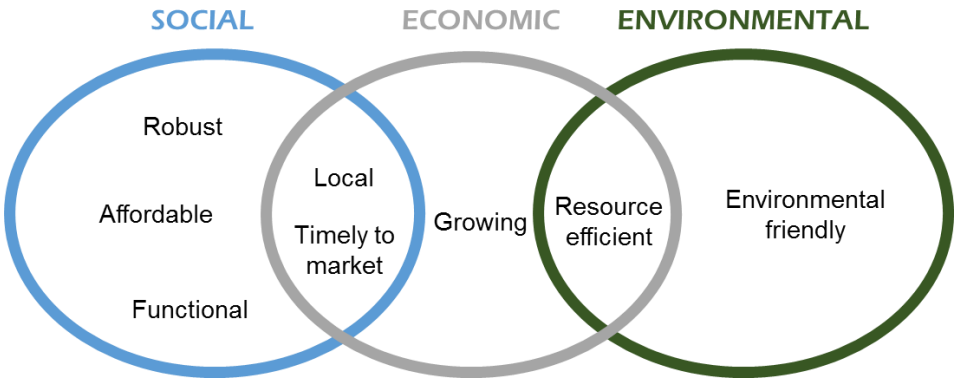


Figure 3: Sustainability and Frugal Innovation characteristics

A brief description of the selected eight core competences was following performed to understand their importance in the conceptualization of the frugal solutions.

Robust

Frugal innovations demand a high level of stability to face of variations in operating environment (Kumar and Puranam, 2011). The extreme climate conditions and frequent power cuts are challenging for companies to achieve quality and consistency (Soydan, 2012). Thus, frugal products need to have high robustness for rough use conditions (Zeschky et al. 2014; Roland Berger Strategy Consultants 2015).

Affordable

Efforts on the frugal product development must consider affordability constrains (London and Hart, 2011). “As frugal innovations target users whose financial resources are extremely limited, they must be highly affordable and propose only the functionalities that are truly essential in these customers’ eyes.” (Angot and Plé 2015). Currently, there are several examples of frugal innovations that cost between 50% and 97% less than regular corresponding products (Rao, 2013) and are accessible to all social strata including the less affluent segments (Mukerjee, 2012; Hamacher, 2014)

Functional

In order “to make products and services that actually solve problems” (Radjou and Prabhu 2015), companies should include a strong focus on core functionality. Frugal products are functional when they are designed to be user-friendly, practical and useful (Rocca, 2016). Consumers must intuitively use these minimalist lean-featured offerings (Petrick and Juntiwasarakij, 2011) without prior knowledge.

Local

The use of local support prompts the emergence of sustainable innovations (Soni, 2013). Frugal innovation not only works systematically its way toward the local customer (Roland Berger Strategy Consultants, 2014) but also combine efforts with “local suppliers, local development and R&D, local employees and local distribution channels” (Rosca et al., 2016). This “social embeddedness” (London and Hart, 2011) allows job creation, income generation, education progress and infrastructure building (Kahle et al., 2013) which improves the well-being of local people.

Timely-to-market

The continuous changing environment within emerging markets forces companies to focus on velocity and flexibility (Rocca, 2016). The timely-to-market frugal characteristic, introduced by Siemens, is vital to guarantee an efficient reduction on the time spent between the development phase and the introduction of the product. As reported by Roland Berger Strategy Consultants (2015) “speed takes precedence over perfection; products become established if they get to market early and if they accurately target relevant customer needs”.

Growing

According to Ernst and Young Strategy Consultants (2011), the economic rise of emerging countries induces a rapid growth of the global intermediate layer, which will grow from 1.8 billion humans in 2010 to nearly the triple by 2030. For this reason, the demand for frugal innovations is expected to skyrocket (Engel and Sebaux 2014). The defining feature of this new frugal economy is mass customisation (Radjou and Prabhu, 2015) and companies should use mega scale production to drive costs down (Kumar and Puranam, 2011).

Resource-efficient

An efficient utilization of resources brings benefits in two dimensions: i) In the economic perspective, the less use of materials for both production and maintenance and the usage of recycling materials, allows a substantial procurement and waste cost reduction (Rosca et al., 2016), ii) In the environmental perspective the reduced waste provides a strong ecological impact since waste activities such as incineration, landfill and disposal are no longer needed. In addition, the efficient use of resources is critical to avoid resource scarcity. According to Janez Potočnik, the EU commissioner for the environment, “resource efficiency is where environmental benefits and innovative growth opportunities come together”.

Environmental-friendly

As reported by Bocken and Short (2016), sustainable innovations must have an ecological impact by generating improvements concerning eco-design and eco-efficiency. When developing a frugal innovation’s strategy, companies must incorporate some environmental-friendly measures such as reducing energy, land, emissions and waste (Rosca et al., 2016). However, the fundamental environmental measure that must be followed by frugal innovation’s companies is recycle along the value chain (Radjou and Prabhu, 2015) and integrate circular economy procedures.

2.1.3. Market Characterization

The generic conceptualization of frugal products previously presented in subchapters 2.1.1 and 2.1.2. enabled a theoretical comprehension of the subject. However, in order to assess the practical basis of these products, two key aspects should be formally analysed: 1) the target market of frugal innovations and, 2) the dispersion of frugal products into different industry sectors (fields of activity). Both of these subthemes have enriched the following market characterization whose purpose was, precisely, to evaluate whether the development of frugal products could have a prosperous future in the global market.

2.1.3.1. Target Market

The frugal innovation guiding principle "*do more with less for more people*" proposed by Bhatti and Ventresca (2013) can be used as the starting point of a detailed analysis of the characterization and potentialities of the target market. The term "*do more with less*" reinforce the idea of *doing more* by offering affordable and quality products but *using less* due to the high resource constrains and scarcity. The second part of this principle – i.e., "*for more people*" - emphasises the importance of reaching the requirements of a large number of people. As the sales are driven by two components, price and volume, and as frugal innovations are affordable (meaning that they are low price solutions), the focus for the selling strategy of frugal innovations should be on increasing the volume of sales.

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).

Since the goal is to serve a great number of consumers, i.e., high volume, the characteristics and future directions of both, emerging and developed markets, should be analysed. The purpose of this analysis was to reinforce the idea that frugal innovation fits precisely with the current situation of these two studied markets.

Emerging Markets

The prospects for developing economies are tremendous and there are six fundamental disruptive trends that are fostering the adoption of frugal products by emerging markets.

(1) **Business opportunity**: In 2014, emerging markets accounted 36% of the global GDP and estimates indicate a business opportunity of US$30 trillion by 2025 (Kondis and Stehli, 2014). Currently, most multinational companies are poorly exploiting this opportunity and just earn 17% of the total revenue available in these markets (Kondis and Stehli, 2014).

(2) **Population growth**: It is expected that in the year of 2030, 95% of the global population growth will take place in emerging markets (Kharas, 2010) with almost 7 billion people (United Nations, 2015) living in developing countries. These huge markets are seeking for new solutions or existing solutions but delivered in new ways (Soni, 2013).

(3) **Increasing purchasing power:** The developing countries economic rise induces a quick growth of the global middle class expecting to grow from 1.8 billion individuals in 2010 to reach 4.9 billion of

individuals by 2030 (Kharas, 2010). From this increase, 85% will come from the Asian continent (Kharas, 2010; Roland Berger Strategy Consultants, 2013), and 40% of the consumption is predicted to be generated in China and India (Ernst and Young Strategy Consultants, 2011).

(4) **Existence of basic needs:** In emerging markets, there are billions of customers who still have basic needs (Prahalad and Mashelkar, 2010) such as access to clean drinking water and energy sources and healthcare and education services (Soni, 2013). Since frugal solutions are affordable and functional, the simplicity must be safeguarded and it is easier to incorporate this simplicity on products that satisfy the basic needs.

(5) **Availability of local materials and workforce:** Emerging markets hold the key aspect of a well-integrated business strategy: local talent (Soni, 2013). The local physical materials allow a less costly procurement since the raw materials do not need to be imported and the local labour resources generate a more unified link between the company and the communities since the workers are one of them.

(6) ***Institutional voids*:** In developing markets, there is significant lack of intermediaries such as lack of physical infrastructures or energy supply. Khanna and Palepu (2010) defend that understanding the meaning of these *institutional voids* would empower sustainable innovations such as frugal innovation (Soni, 2013). In fact, these voids, boost the few existence sources of energy such as the solar energy, and allow the development of environmental-friendly and ecological solutions.

Developed Markets

Identically, the developed markets are also experiencing changing conditions although considerably different from those faced by emerging economies (Howard, 2011). The two disruptive trends following presented, are increasingly contributing to the launch of frugal products and services in developed and matured markets.

(1) **Economic crisis:** According to Hossain (2016), “the economic state of the developed countries is plummeting”. For instance, from 2007 to 2014, the median income of US household has decreased 7.5% (Department of Numbers, 2015) and in Europe, the gross disposable in many countries has also declined. Thus, taking into account the facts suggesting that customers in developed countries are increasingly having less money to spend, they are searching for affordable solutions to meet their tight budgets, and frugal products match those needs (Hossain, 2016)

(2) **Sustainability awareness:** Society is increasingly perceiving the impact of unsustainable activities and are desiring products with beneficial features concerning social and environmental impacts (Rosca et al., 2016). Therefore, frugal innovation not only match those sustainable needs through the core characteristics of its products but also emphasises the importance of a radical drift in the resource and time-consuming behaviours followed by several multinationals (Hossain et al., 2016; Bocken and Short, 2016).

After this analysis, the identification of the target market for frugal innovations in both markets became easier to assess. Regarding the emerging markets, the type of customers willing to buy frugal products is quite homogeneous with the majority valuing the same features: affordability and functionality. Thus, one single group can be considered to encompass the developing economies. The name adopted was

emerging segment. On the other hand, as described before, in developed countries there are clearly two different purchasing motives (affordability and sustainability). Thus, two target segments should be considered: 1) *developed-price-driven segment* and 2) *developed-sustainability-driven segment*.

In order to understand the potential of these three segments described before, a qualitative matrix was designed to assess the evolution between 2017 (today) and 2030 (near-future) (Figure 4). The two key characteristics represented in each axis (disposable income and sustainability awareness) were chosen to clearly understand the differences between segments and the size of each sphere symbolises the size of the market-segments in number of potential consumers. There is no evidence that this kind of approach was ever made in the frugal innovation literature

Figure 4 demonstrates the tremendous potential in terms of volume of possible customers associated with the frugal innovation market. Regarding the size parameter, the three market segments have increased the number of potential consumers between 2017 and 2030. However, the one with greater increase in volume was clearly the *emerging segment* due to its exponential population growth.

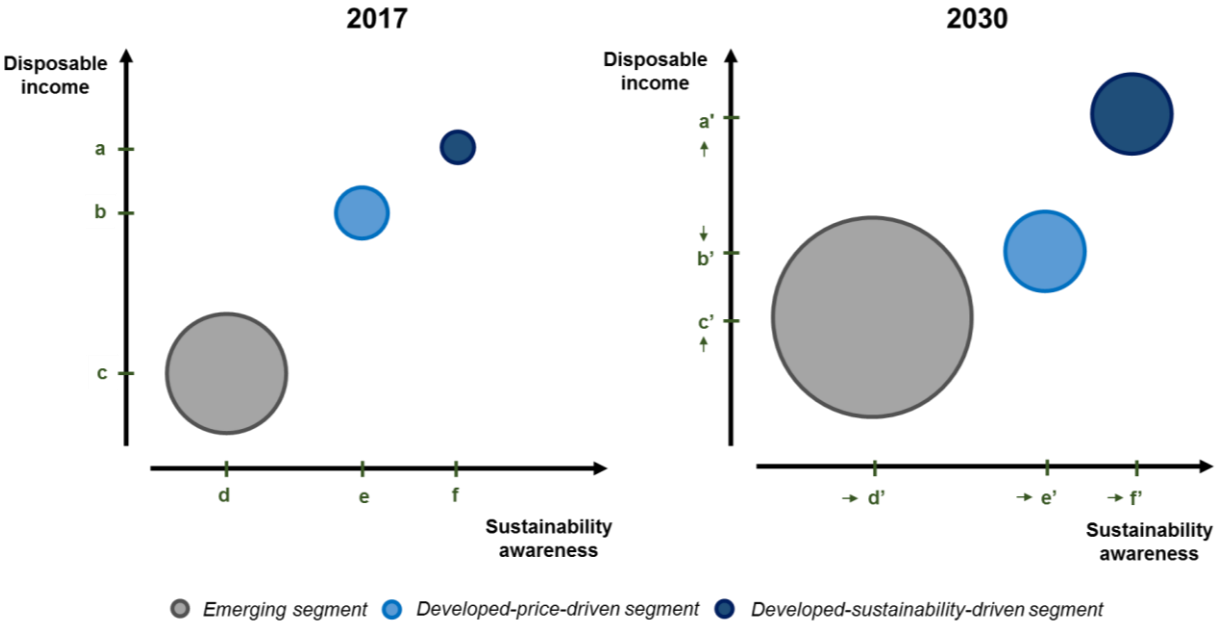


Figure 4: Qualitative matrix to address market segments potentiality for 2017 and 2030

The vertical axis of the matrix represents the mean of the disposable income per year of each segment. As shown in the figure 4, the current average value of disposable income in emerging markets is much lower than in developed economies. However, within the developed market, the segment of individuals who buys the frugal products due to its low price, commonly, have less money to spend than the ones who buy it for sustainable concerns (a>b>c). In 2030, the value of the vertical axis was predictable to change quite significantly, with two major conclusions standing out: 1) the expected middle-class growth in emerging markets will cause a stronger purchasing power which will enhance the average disposable income available on the *emerging segment (c'>c); 2)* The projection for the disposable income in the *developed-price-driven segment* will behave fairly differently due to the expansion of the economic crisis in developed markets. The average disposable income in 2030 will be lower than the one noticed today (b'<b) (Hossain, 2016).

The horizontal axis is totally related to the level of sustainability awareness of each segment. Today, developed economies are much more aware of the benefits associated with environmental prevention and social inclusion than in emerging economies (d<e<f). Nevertheless, in the near future, the three segments will increase their levels of sustainability awareness due to more frequent government and Non-Governmental Organizations (NGO) disclosures about sustainability issues (d'>d; e'>e; f'>f).

In the beginning of this subchapter it was highlighted that the goal of frugal innovation is to achieve a considerable volume of customers and that the purpose of the previous analysis was to assess whether developed and emerging markets enabled a good expansion for frugal products. After this study, it is clear to conclude 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.

2.1.3.2. Fields of Activity

The future success of frugal innovation in the global market not only depends on the customers (target market) but also depends on the scope of sectors (fields of activity) in which frugal products can be employed. Thus, the dispersion of frugal products into the different industry sectors should be analysed to assess whether the diversity of categories is boosting the expansion of this type of innovations. Some researchers have developed sectorial analysis in which the market was divided in several industry sectors (Hossain, 2016; United Nations Development Programme, 2014). Based on those analysis, and after a frugal innovations research, nine fields of activity were selected for further investigation: agriculture, energy, food and water, transportation, healthcare, electronic, education, finance and shelter and living conditions.

Aiming at understanding how frugal products can have different applications according to the sector for which they are intended, the table 1 was created.

Table 1: Frugal innovations by market sectors

Sector	Company Name	Product
Agriculture	gThrive	**Name:** gStakes **Description:** A maintenance-free wireless sensors made of lightweight plastic which when implanted in the field, measure and track soil and environmental conditions. The collected data helps farmers to reduce their water and fertiliser use (Radjou and Prabhu,2015) and allow a more efficient and optimized decision making (gThrive, 2015).
Energy	Greenlight Planet	**Name:** Sunking Home 60 **Description:** A modern solar lighting and energy hub for homes living off the electric grid. The solution diffuses fixed room lighting to three separate rooms and is supported by a 5-year lifetime battery (Sunking, 2017).
Food and Water	ChotuKool	**Name:** ChotuKool **Description:** A portable, compact and lightweight fridge which maintains the humidity and nutritional value of your food with low power consumption. It works on inverter or external battery and retains cooling up to 3 hours without power (ChotuKool, 2014).
Transportation	Eco Motion	**Name:** Freeliner **Description:** An electrically-driven three-wheeled bike boards highly efficient, virtually noiseless and maintenance-free. This solution with a range up to 70 km is suitable for people with and without a physical disability who want to be mobile and take an active part in life (Eco Motion Solutions, 2017).
Healthcare	Embrace	**Name:** Embrace Infant Warmer **Description:** A ultra-low cost, small and light portable infant incubator designed to help millions of vulnerable babies in developing countries (Angot and Plé, 2015).
Electronic	Datawind	**Name:** Ubislate 7 **Description:** A table that is the most affordable one in the gadget world. Developed in India, this device is fully equipped with a high-speed processor and sensational picture quality (Datawind, 2016).
Education	Foldscope Instruments	**Name:** Foldscope **Description:** An origami paper microscope designed to be produced affordably, to be durable and to give optical quality similar to conventional research microscopes (Foldscope, 2016).
Finance	Vodafone	**Name:** M-Pesa **Description:** A mobile phone based payment service that allows users to withdraw at small shops and transfer money much more easily (Vodafone Group, 2017).
Shelter and living conditions	Rematerials	**Name:** ModRoof **Description:** A modular roofing system for slum and village homes where the main component are panels that are custom manufactured from packaging and agriculture waste (Ellen MacArthur Foundation, 2016)

In addition, in order to understand the dispersion of the existing frugal innovations into the different industry sectors, the complete list of 61 frugal innovation cases developed by Rocca (2016) was considered. The innovations addressed on this list were divided into the nine categories previously mentioned according to their purpose. Figure 5 synthesizes the findings.

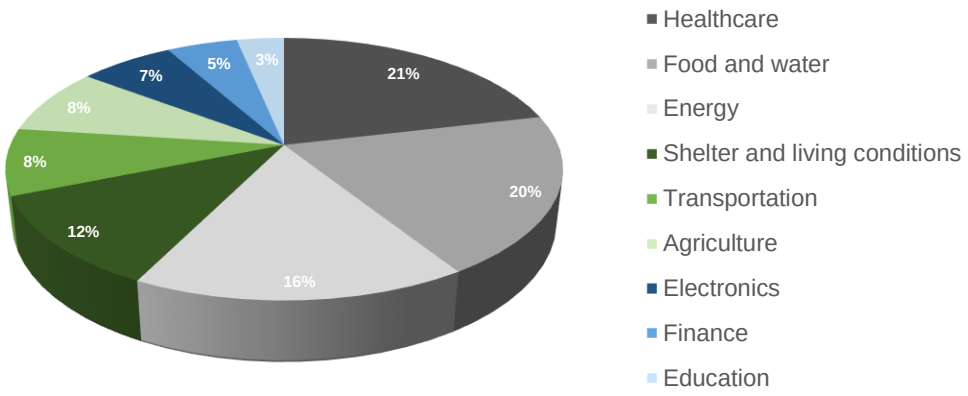


Figure 5: Frugal innovation distribution by market sector

Based on the figure 5, some concluding topics must be highlighted.

(1) More than half of the selected list of frugal innovations belong to the **healthcare**, **food and water** and **energy** sectors (35 products out of 61). This reality is directly related to the fact that, currently, the majority of the developed products are intended for emerging markets where the basic needs still exist in high intensity.

(2) In the near future, it is hoped that areas such as **education** and **finance** that today have little attention (35 products out of 61), will significantly become more explored. Thus, there will be a fairly equitable distribution among the several areas of application.

(3) As presented in the section 2.1.3.1., both, emerging and developed markets, have a high frugal innovation market potential so it is expected that the number of frugal products will increase exponentially in the following years (>61 products).

In the beginning of this subchapter it was highlighted that the future of frugal innovation also depends on the scope of sectors in which frugal products can be employed. As previously concluded, the field of activity of frugal innovation is extremely broad and new developments can be invented in all sectors. Thus, a favourable situation was definitely created in order to initiate frugal innovation expansion.

2.1.4. Frugal Innovation Literature Review

The general theoretical and practical insights of frugal innovation were previously addressed, starting with the definition and core characteristics of frugal products and followed by the market characterization. However, the state-of-the-art of frugal innovation is still to be analysed. Thus, a comprehensive and thorough literature review, resulting in a collection of papers and other relevant scientific documents, was performed aiming 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; namely Elsevier/ScienceDirect, ResearchGate, b-on, EBSCOhost, and Google Scholar. Since the boundaries of the search are closed to the theme in analysis, the keyword "frugal innovation" was the only one used in the search process. All the material collected for the purpose of this investigation was in English.

This research returned more than 100 documents which included journal and conference articles, book chapters and company reports. However, after the first data treatment, only 41 articles were selected for further investigation. Most of the removed documents just mentioned frugal innovation without really focusing on the subject and some did not follow an academic purpose.

In order to draw some conclusions, the content of the remaining 41 documents was meticulously analysed. The following eight main frugal innovation subjects were considered:

- C – Conceptualization: definition and core characteristics.
- FE – Frugal Examples: practical examples of frugal products and services.
- SC – Similar Concepts: keywords such as 'Reverse Innovation', 'Bottom of the Pyramid (BoP)', 'Inclusive Innovation', 'Jugaad' and 'Resource-Constrained Innovation', 'Grassroot Innovations'.
- M – Market: emerging and/or developed markets characteristics.
- BM – Business Model: enterprise operations such as controlling, monitoring and planning.
- SCM – Supply Chain Management: flow of goods and services and SCM stakeholders.
- SG – Sustainability in General: three pillars of sustainability (at least one was broadly analysed).
- ES – Environmental Sustainability: environmental impacts and practices (detailed analysis).

When an article addressed some of these main subjects, a check mark was placed in the intended rectangle. The table 2 synthesizes the findings.

Table 2a: Summary of the literature review on frugal innovation

Year	Researchers	C	FE	SC	M	BM	SCM	SG	ES
2011	Zeschky et al.	✓	✓			✓			
2012	Bhatti	✓	✓	✓	✓				
2012	Tiwari and Herstatt	✓	✓	✓	✓				
2012	Soydan	✓	✓	✓	✓				
2012	Agarwal and Brem	✓	✓	✓	✓				
2012	Bound and Thornton	✓	✓	✓	✓	✓			
2013	Tiwari and Herstatt	✓			✓				
2013	Kahle et al.			✓	✓				
2013	Rao	✓	✓						
2013	Bhatti and Ventresca	✓	✓	✓	✓		✓		
2013	Basu et al.	✓	✓	✓			✓	✓	
2013	Brem and Ivens		✓	✓	✓			✓	
2013	Soni	✓	✓		✓	✓			

Table 2b: Summary of the literature review on frugal innovation (cont.)

Year	Researchers	C	FE	SC	M	BM	SCM	SG	ES
2014	Tiwari and Herstatt	✓	✓	✓	✓				
2014	Zeschky et al.	✓	✓	✓					
2014	Tiwari et al.	✓	✓						
2014	Brem and Wolfram	✓		✓					
2014	Radjou and Prabhu					✓	✓		
2014	Rao							✓	
2014	Hamacher	✓	✓			✓	✓		
2014	Zeschky et al.		✓	✓					
2015	Simula et al.	✓	✓	✓	✓				
2015	Levänen et al.		✓					✓	
2015	Angot and Plé	✓	✓			✓		✓	
2015	Khan and Haldar	✓	✓						
2016	Pansera and Sarkar		✓	✓				✓	
2016	Altmann and Engberg					✓	✓		
2016	Hossain	✓	✓	✓	✓				
2016	Lehner and Gausemeier	✓	✓			✓	✓		
2016	Colledani et al.					✓	✓		
2016	Rosca et al.	✓	✓	✓	✓	✓	✓	✓	
2016	Knorringa et al.	✓	✓						
2016	Wohlfart et al.	✓	✓	✓				✓	
2016	Mourtzis et al.					✓	✓		
2016	Belkadi et al.					✓	✓		
2016	Hossain et al.	✓	✓	✓	✓				
2016	Weyrauch and Herstatt	✓	✓	✓					
2016	Tiwari	✓			✓				
2016	Rocca	✓	✓	✓	✓	✓	✓	✓	
2016	Khan	✓	✓					✓	
2016	Numminen and Lund	✓	✓		✓			✓	
		30/41	28/41	21/41	18/41	13/41	11/41	11/41	0/41

Through the information synthesized in table 2., the evolution of the content of frugal innovation documents can be analysed and the subjects that have major potential to be explored in further investigation can also be identified.

Regarding the evolution of the subjects addressed in frugal innovation documents, there are two subjects that have increasingly calling the attention of practitioners and scholars, Supply Chain Management (SCM) and Sustainability in General (SG). Both subjects have started to be progressively addressed, four years after the publishing of the first frugal innovation document, in 2011. In fact, the turning point was achieved in 2015 when the need of expanding the conceptual boundaries of frugal innovations become a requirement. The increase attention on supply chain and sustainability matters is totally related with the current atmosphere of material and energy losses, disposal behaviours and non-environmental-friendly practices that are being followed by economies around the world (Semenova and Hassel, 2015). Scholars and academics have identified an opportunity on frugal innovation and more than developing the conceptualization of the term, they understood that implementing frugal innovation can effectively boost sustainable practices as well as increase the efficiency of resource utilization through a responsible supply chain management. (Rocca, 2016).

Concerning the subjects that have major potential to be explored in further investigations, and following the previous reasoning, Supply Chain Management (SCM) and Sustainability in General (SG) definitely represent the areas that are more attractive to be explored. In fact, the literature is far from saturated since only 27% of the documents addressed SCM and 27% addressed SG. The same does not apply to the subjects of Conceptualization (C), Frugal Examples (FE) and Similar Concepts (SC) whose insights were addressed by a substantial number of authors and frugal innovation literature is already matured regarding these topics.

After these analysis, the two subjects SCM and SG were analysed in greater prevalence and one significant conclusion stood out. Until now, any document has focused on the Environmental Sustainability (ES) of frugal innovation. One more column (ES) was added to the table 2 in order to highlight this evidence. In fact, it is shown in table 2, that the last column is fully empty. Thus, the Environmental Sustainability 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 Environmental Sustainable Development

This chapter presents the theoretical and practical topics of interest to address the relevant knowledge about circular economy. Section 2.2.1. addresses the evolution of industrial economy from linear to circular economy. In Section 2.2.2., a broadly conceptualization of circular economy was performed in order to understand the relationship between its three main principles and the 6R's actions. The Section 2.2.3. enumerates the three key-actions that every circular economy strategy has to follow in order to be flourishingly succeed. In Section 2.2.4., a win-win-win atmosphere was analysed in order to explore the most relevant circular economy advantages for economies, companies and consumers/users. Finally, the last section (Section 2.2.5) sums up the evidences acquired along the research as well as subsequent implications and conclusions.

2.2.1. From Linear to 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). This linear model of resource consumption, also known as neoclassical economics, mainly focuses on efficient allocation of resources in the market (Ghisellini et al., 2016). However, an economy whose focus only relies on working towards efficiency enables the reduction of resources and energy consumed per unit of manufacturing output (Ellen MacArthur Foundation, 2012) but "fails in providing analytical tools that take into account the limited nature of natural resources" (Ghisellini et al., 2016). Essentially, this linear consumption behaviour is just delaying the inevitable (Ellen MacArthur Foundation, 2012).

Currently, our economy is still locked into a system where regulation and mindset favours the linear system of production and consumption (Ellen MacArthur Foundation, 2012). Moreover, through most of

the past century, the decline of resource prices has also sustained this behaviour given the ease of obtaining new and cheap input materials (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). Ellen MacArthur Foundation (2012) studied the negative impacts of the 'take-make-dispose' model on society and divided the unnecessary resource losses in four categories:

(1) **Waste in the production chain:** Significant volumes of materials are frequently lost in the production chain. In fact, OECD countries consume over 21 billion tonnes of materials that are not physically integrated into the products themselves (Ellen MacArthur Foundation, 2012).
(2) **End-of-life waste:** The rates of recovery after the end of the first functional life for most materials are considerably low. For example, in Europe, 2.7 billion tonnes of waste were generated in 2010, but only about 40% was reused, recycled, or composted (Ellen MacArthur Foundation, 2012).
(3) **Energy use:** There are two significant ways of losing energy through the linear model: 1) the residual energy is lost in the disposal activity of a product and 2) an exceeding quantity of energy is consumed in the transformation of a new rather than a recycled material.
(4) **Erosion of ecosystem services:** The earth's natural capital is being constantly compromised by the unsustainable practices performed by humanity (Steffen et al., 2011). In fact, 15 of the 24 ecosystems examined by The Millennium Ecosystem Assessment are being unsustainably used (Ellen MacArthur Foundation, 2012).

As reported by Ghisellini et al. (2016), this "negative effects caused by linear consumption are threatening the stability of the economies and the integrity of natural ecosystems that are essential for humanity's survival". Several companies have begun to notice how linear economy also intensify their exposure to risks in terms of high resource prices and supply disruption (Ellen MacArthur Foundation, 2012). Governments are similarly beginning to realize that the current model also impose increasing threats to welfare and wellbeing of society (Wijkman and Skånberg, 2015) since it pays no attentions to ecological and social concerns (Sauvé et al., 2016). The volumes of waste and pollution generated is becoming worrisome (Lieder and Rashid, 2016) and the model 'take-make-dispose' is reaching its physical limits (Ellen MacArthur Foundation, 2015b).

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 Steady-State Economy**. The purpose of this economy is to fill the gap imposed by the linear model (Ghisellini et al., 2016). In fact, the latter did not take into account the finite nature of resources and steady state economy endeavours "trying to keep the economic activities within the constraints imposed by nature" (Ghisellini et al., 2016). Steady-state pays attention to the inner justice of future generations and defends that individuals must not only meet the demand of the present, but also not harm the capacity of meeting the future energy and resource demand (Xia and Yang, 2007). This model interprets the environmental parameter from the matter and energy constrain point of view which is imposed by the laws of thermodynamics (Ghisellini et al., 2016).

Xia and Yang (2007) also presented the fundamentals of this new approach where they defend that "steady-state economy represents the balance between two systems: human system and material wealth system". A vital rule must be followed in order to achieve a sustainable steady-state: both systems must be kept at a low flow rate. It should be noted that regarding the demographic system, a low flow rate means a low rate of birth and death i.e. high life expectancy. For the material wealth system, a low rate intends a low and controlled rate of resource extraction. It is easy to assess that the void of this model is directly related to this utopian balancing since it is quite challenging to maintain both rates at a low stream (Prendeville, 2014). Firstly, at a global scale, population is continuously growing and it is relatively difficult to sustain a low rate of birth. Secondly, the middle-class is also intensifying its position and increasingly demanding more products. Certainly, a low rate of resource extraction can be supported by an increase in the durability of products and commodities but the actual and future demand overrides this time improvements.

While great efforts have been made in refining resource efficiency, "any system based on consumption rather than on the restorative use of resources entails significant losses all along the value chain" (Ellen MacArthur Foundation, 2012). Thus, a strong model emerges as a major prerequisite to stay within the planetary boundaries: **The Circular Economy** (Wijkman and Skånberg, 2016). This restorative and regenerative economy (Ellen MacArthur Foundation, 2015a) 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, 2015a), i.e., society can continue to consume goods and services but not depending on the extraction of virgin resources (Sauvé et al., 2016). Due to this tremendously important fact, circular economy deserves a special attention and should be studied in detail in order to provide a valuable comprehension of its insights.

2.2.2. Conceptualization

The background and history of circular economy was already studied. However, some essential questions about the concept remain unanswered. In this subchapter, a sterling and easily-comprehended conceptualization of the circular economy concept was developed in order to understand some crucial information about this burning topic among scholars and policy-makers (Geissdoerfer et al., 2017; Winans et al., 2017). Subjects such as the first appearance of the concept, the main principles of circular economy and the importance of the 6Rs (Reduce, Recover, Reuse, Remanufacture, Recycle, Redesign) will be following explored.

According to several authors, the concept of "circular economy" has been first raised by two British environmental economists, Pearce and Turner, in 1989 (Andersen, 2007; Su et al., 2013; Ghisellini et al., 2016, Geissdoerfer et al., 2017). The concept was introduced in *Economics of Natural Resources*

and the Environment where the two environmentalists “pointed out that a traditional open-ended economy was developed with no built-in tendency to recycle, which was reflected by treating the environment as a waste reservoir” (Su et al., 2013).

There is a significant amount of theories that have performed an important contribution for the further development and refinement of circular economy conceptualization and definition (Ghisellini et al., 2016; Sauvé et al., 2016; Geissdoerfer et al., 2017). Some of the most relevant theoretical influences are laws of ecology (Commoner, 1971), regenerative design (Lyle, 1994), industrial ecology (Graedel and Allenby, 1995), cradle to cradle (McDonough and Braungart, 2002), performance economy (Stahel, 2010) and blue economy (Pauli, 2010).

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:** A key role performed by the circular system is to select the resources wisely and choose the processes and technologies that use renewable or better-performing resources. Whenever possible, the practices that are compromising the natural capital must be eliminated and replaced by sustainable activities (e.g., replacing fossil fuels with renewable energy).

(2) **Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles: “**A model of production based on a circular economy may seek to extend the useful life of the product i.e., delay its end-of-use” (Sauvé et al., 2016). The only way to guarantee this requirement is through the utilization of some techniques such as remanufacture, recover, reuse and recycle that allow successive closed loops flows of material (Geissdoerfer et al., 2017). The use of these practices boosts waste-free systems (Wijkman and Skånberg, 2016) and reduces disposal needs.

(3) **Foster system effectiveness by revealing and designing out negative externalities:** A negative externality can be defined as the cost suffered by a third person or society as a whole resulting from an event (Ellen MacArthur Foundation, 2016). These externalities, among others, include all the types of pollution (such as air, water and noise pollution), climate changes, congestions and health effects such as obesity, asthma or allergies. Circular economy aims to reduce the damage caused by these externalities (Su et al., 2013; Sauvé et al., 2016) in order to be a harmonizing solution for the future (Lieder and Rashid, 2016).

Besides Ellen MacArthur Foundation (2015), several authors such as by Braungart et al. (2007), Zhang et al. (2013) and Jawahir and Bradley (2016) have also developed important studies that have strongly contributed to the circular economy conceptualization. These works were incorporated into one single model, exhibited in figure 6, in order to accomplish an understanding of the most relevant characteristics of a circular economy. It should be noted that the circular economy diagram developed by Ellen

MacArthur Foundation (2012) was analysed in greater prevalence and it represents the basis of the following model.

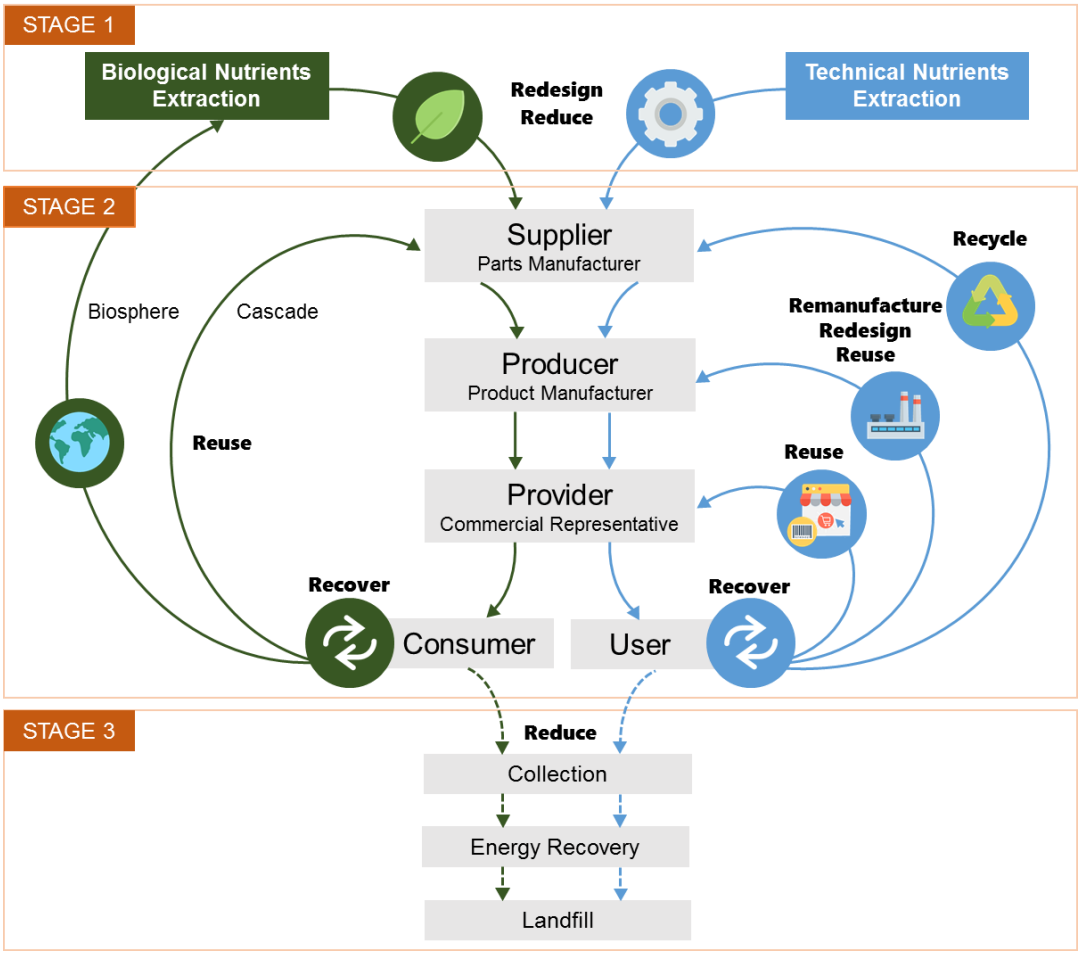


Figure 6: The circular economy - Adapted from Ellen MacArthur Foundation (2012)

Before a detailed analysis of the main features of the model, an overall perspective must be initially described. The model begins with the extraction of resources (stage 1). These resources can be biological or technical depending on its nutrients and characteristics. Both, have their own cycle in which the green one corresponds to the biological cycle while the blue one corresponds to the technical cycle. The extraction of resources is usually performed by the supplier who rearranges the raw material into parts or components in order to facilitate producer tasks. Then, the producer manufacturers the final product according to some specifications and these products are delivered to some commercial representatives who sell the products to consumers or users, depending on the cycle. In the biological cycle, the nutrients are called products of consumption due to the easy and fast decomposition. That is why the buyers are considered to be consumers. In the technical cycle the buyers are called users since technical product are made to be used and not consumed. As stated before, when the product is no longer suitable for its originally intended purpose, the product has two possible destinations: can initiate the circular path through the recovery activity (stage 2) or can be collected to initiate the disposal and landfilling process (stage 3). Although stage 2 is the basis of circular economy, the stage 1 and 3 were

also incorporated into the model to emphasise the importance of reducing both, the extraction of raw material (mainly the technical nutrients) and the amount of waste generated.

The generic description of the model was stated. However, the model is composed by a significant number of relevant elements and every detail should be formally defined. Thus, two categories were considered to better understand the concepts incorporated in the model: 1) biological and technical cycles and 2) 6Rs definition.

Biological and technical cycles

McDonough and Braungart (2002), defend that there are two distinct ways of turning materials into nutrients: by the biological metabolism and by the technical metabolism. Thus, the model presented in the figure 6, clearly distinguishes between biological and technical cycles.

Regarding the former, the materials that flow optimally through the biological metabolism are called biological nutrients. These nutrients are biodegradable materials that can be returned to the natural environment after use to feed biological processes since they poise no immediate or eventual hazard to living systems (McDonough and Braungart; 2002). Biological nutrients can be natural or plant-based materials or can be textiles, brake pads, shoed soles and other materials that may be consumed during their lifespan (e.g., through physical degradation or abrasion).

The latter involves technical nutrients that commonly are synthetic or mineral materials (as metals and plastics) that have the potential to remain safely within a closed-loop system (McDonough and Braungart; 2002; Ellen MacArthur Foundation, 2012; Ghisellini et al., 2016). The idea is to extent their value through many product life cycles in order to arise mutual benefits to the manufacturer and to the customer. “The manufacturer maintains ownership of valuable material assets for continual reuse while the customers receive the service of the product without assuming its material liability” (McDonough and Braungart, 2002).

6Rs Definition

Circular economy mainly emerges in the literature through three main action, i.e. the 3R principles: Reduce, Reuse and Recycle (Feng and Yan, 2007; Sakai et al., 2011; Preston, 2012; Su et al., 2013; Lett, 2014; Ghisellini et al., 2016). Jawahir and Bradley (2016), based on work developed by Zhang et al. (2013), reinforced the importance of the inclusion of a 6R-methodology rather than 3R in the circular economy conceptualization. They defend the necessity to introduce three more elements that they found relevant: Redesign, Recover and Remanufacture. After a substantiated research, it was revealed that all the 6R element can actively perform an important role in the circular economy model. In fact, the inclusion of these six elements in the application of circular economy “can lead to the ultimate end goal of sustainable value creation in the economy, society and the environment” (Jawahir and Bradley, 2016) and that is why all these principles were incorporated into the model.

The definitions of these six concepts are the following:

(1) ***Reduce*****:** This principle aims to minimize three types of losses: the input of raw materials, the primary energy and the waste through the improvement on production efficiency (Su et al., 2013; Ghisellini et al., 2016).

(2) ***Recover*****:** This principle mentions the "process of collecting products at the end of the use stage, disassembling, sorting and cleaning for utilization in subsequent life-cycles of the product" (Jawahir and Bradley, 2016). It is through recovery that products can be further reused, remanufactured of redesigned, i.e., the product recovery is the first action in the circular path.

(3) ***Reuse*****:** This element refers to any operation by which products and components that are not waste are used again, after their first life-cycle, in subsequent life-cycles (Ghisellini et al., 2016; Jawahir and Bradley, 2016). The idea is "to use products to its maximum capability with frequent maintenance and reclamation to prolong its endurance" (Su et al., 2013).

(4) ***Remanufacture*****:** This element involves the restoration of a product into the original state or a like-new form through the re-processing of some components that were retained by the reuse activity due to functionality losses (Jawahir and Bradley, 2016)

(5) ***Recycle*****:** According to EU (2008), the recycle principle refers to "any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes" (Ghisellini et al., 2016). These materials would otherwise be considered waste (Jawahir and Bradley, 2016) and following this new path they can be converted without damaging the environment well-being (Cagno et al., 2005; Zhu, 2008; Lazarevic et al., 2010, Birat, 2015; Ghisellini et al., 2016).

(6) ***Redesign*****:** This activity involves the act of redesigning the next generation of products (Jawahir and Bradley, 2016) and the processes of the whole circular chain in order to increase its efficiency (Ellen MacArthur Foundation, 2012).

The supreme goal of a circular economy is to achieve a purely circular industry system branded by the low extraction of raw materials (stage 1) and by its waste-free characteristics (stage 3). However, this goal can only be accomplished through the support of some important movements, i.e., through the implementation of the three main principles of circular economy and of the 6R actions. Thus, an excellent way to achieve an inclusive comprehension of the circular economy model is through a detailed analysis of the relationships between these elements. The following paragraphs demonstrate which R's are the most vital to guarantee that the three main circular economy principles are being pursued.

The first principle, preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows, encompasses the entire supply chain (stages 1, 2 and 3). The actions ***reduce*** and ***redesign*** perform a crucial role in the development of this principle. Regarding the first action, a ***reduction*** is needed in the extracting activity since the amount of resources removed from biosphere must be reduced to guarantee a prosperous and sustainable future (Sauvé et al., 2016) but it is also needed in the end of the process to avoid waste discharge in landfills (Ghisellini et al., 2016; Geissdoerfer et al., 2017). Along the supply chain, the energy consumption and harmful emissions must also be reduced. Regarding the second action, ***redesigning*** the entire supply chain processes (Ellen

MacArthur Foundation, 2012), in particular production activities (Ghisellini et al., 2016), is fundamental to achieve a balancing renewable resource flow. The processes must be redesign, restoratively and regeneratively, Ellen MacArthur Foundation, 2012), in order to avoid imprudent resource or energy losses. This redesigning can be achieved by introducing better technologies (Feng and Yan, 2007; Su et al., 2013) to make processes more efficient or by placing "renewable energy as the main energy source for circular economy to reduce fossil energy dependence and enhance the adaptability (resilience) of the economic system towards oil negative effects (increase in oil prices, lack of supply, etc.)" (Ghisellini et al., 2016). Besides changing the processes, the products must also be redesigned in the beginning to ensure that the other R-actions, i.e., recover, reuse, remanufacture and recycle, are able to perform their circularity role.

The second principle, optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles, only encompasses the circular part of the supply chain, i.e., stage 2. This principle defends the utility extension of biological and technical materials to its maximum capacity using ***recover***, ***reuse***, ***remanufacture***, ***redesign*** and ***recycle*** activities. In this particular case, both, biological and technical cycles, must be distinguished in order to allow an understanding of the possible ways to reintroduce the material again into the chain McDonough and Braungart (2002).

When a biological nutrient is no longer suitable for its envisioned purpose, the material can be ***recovered*** and reincorporated in two ways: 1) the material is returned into biosphere to initiate its restorative behaviour or 2) the material is ***reused*** to fulfil a different purpose (known as cascade procedure) (Ellen MacArthur Foundation, 2012). While the first way of reintroducing biological nutrients into the cycle is quite usual due to its biodegradable characteristics, the second way is a key feature of circular economy success. In fact, reusing biological nutrients is differentiator and offers terrific cascading opportunities. Using the textile industry as an example, a piece of cloth made of cotton or wool, i.e., biological raw materials, in the end of its life cycle can be reused as stuffing in upholstered furniture, car seating or mattresses. When the wadding is no longer suitable it can be recovered again and reused in heat and sound insulations. These consecutive cascades have a tremendous potential since avoid excessive extractions of raw virgin materials (Elia et al., 2017; Geissdoerfer et al., 2017).

Regarding the technical materials, the reintegrating activities can be described using the stakeholders as support. When the user discards a technical product, the ***recovering*** process initiates. The condition of the material is evaluated to assess its next destination. If the whole product is in good condition, the product will be entirely ***reused*** to fulfil the same purpose. It will be send to a commercial representative who will resell the product to another user. If the product as a whole is not able to serve its original purpose, it should be disassembled and sorted to assess which components can be ***reused***. In this case, the producer collects the acceptable parts and can ***remanufacture*** the initial product using these recovered components. However, sometimes it is hard to incorporate directly these elements and it is essential to ***redesign*** some of the production in order to incorporate all the recovered components into new products. The remaining part of the product that was not reused i.e., forwarded to the commercial representative or producer, initiates its ***recycling*** activity and reincorporate the cycle through the

supplier. “Although circular economy is often identified with the recycling principle, it must be underlined that this may be the least sustainable solution compared with the reuse principle in terms of resource efficiency and profitability“ (Stahel, 2013). In fact, the recycling action is limited by nature and by the complexity of materials and some of them are recyclable until a certain point or even unrecyclable (Ghisellini et al., 2016). However, resilient efforts are being made to increase recycling capabilities in order to reduce the amount of waste generated.

Circular economy emphasizes the importance of selecting wisely the type of products incorporated in the supply chain, in particular in the production channel. Products that cannot be composted, reused or recycled must not be produced and consumers and users should not buy it (Ghisellini et al., 2016). The costs of disposal and recovery must be transferred to the producers who will therefore, have a strong incentive to perform the 6R-activities that are crucial to achieve a successful and environmental sustainable circular economy (Ghisellini et al., 2016).

The third principle, foster system effectiveness by revealing and designing out negative externalities, similarly to the first one, also encompasses the entire supply chain (stages 1, 2 and 3). The actions ***reduce*** and ***redesign*** perform an important role in the applicability of this principle. The goal is to ***redesign*** the supply chain to ***reduce*** the damage caused by the negative externalities created by the atmosphere of excesses. There are thousands of negative externalities linked with the over extraction of resources form earth, with overproduction, with over use of non-renewable energy, with huge amounts of waste generated and with other practices that are destroying our planet and society (Elia et al., 2017).

Concluding, pursuing the three principles of circular economy is crucial to boost world economy into a new era of sustainable opportunities. In this subchapter, some circular economy actions were broadly addressed. However, the principles of circular economy can only be strongly pursued through the implementation of some broad activities that perform a vital and distinctive role in circular economy triumph.

2.2.3. Circular Economy Activities Review

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.

Circular economy worldwide implementation seems to follow two different patterns (Ghisellini et al., 2016). One pattern is known as the *top-down approach* where circular economy implementation is promoted within a national political programme and it is considered “part of a wider policy for economic transformation and development” (Naustdalslid, 2014; Ghisellini, 2016). The other pattern is identified as the *bottom-up approach* where environmental and waste management policies and initiatives are being adopted by companies, civil society and NGO, who are constantly trying to push green movements into national policies. These two approaches follow different patterns, methods and tactics. However, 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 five 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.

The goal of the literature review was to assess the similarities between the eight documents in terms of activities that are being adopted in circular economy strategies. It was found that all documents seem to address, implicitly or explicitly, the same broad activities (see columns of Table 3). However, the taxonomy differs from document to document. Thus, table 3 was created in order to illustrate the activities described in each study. In the current document, all these activities were further classified into the new taxonomy.

From Table 3, it was possible to verify the disparity of activities described in the different documents, under the same goal. For instance, the eight documents used terms such as ‘appropriate design’, ‘green design’, ‘design for environment’, etc, to describe the design activity in a circular economy strategy and the term ‘eco-design’ was the term assigned to combine all these different contributes. Besides ‘eco-design’, the terms ‘greem procurement’, ‘cleaner production’, ‘service economy’, ‘sustained lifespan’ and ‘recovery economy’ were also selected. The selection of these concepts was clear for some activities and not so obvious for others. Thus, a new taxonomy with different definitions, which have arisen from the literature review are presented and described as follows.

Table 3: Summary of the literature review on circular economy taxonomy

	Eco-Design	Green Procurement	Cleaner Production	Sustained Lifespan	Recover Economy
Ellen MacArthur Foundation (2012)	- Appropriate design - Restorative or regenerative by intention and design - 'Design out' waste - Circular design	- Material selection	- Material productivity - Eco-efficiency - Continuous efficiency gains in energy and water consumption	- Extend product longevity	- Reuse after the first cycle - Cascade/reverse skills - Closed-loop re-engineering or recycling - Recovery and reutilisation - Energy recovery
Su et al. (2013)	- Eco-Design - Green Products	- Green consumption and purchase	- Cleaner Production - "Cleaner Production Promotion Law" - Effectiveness of resource allocation, resource utilization and productivity.		- Minimizing the amount of discharge waste and minimizing the use of virgin materials - Reuse and recycle - Product recycle system - Law on Pollution Prevention and Control of Solid Waste - Closed Loop Material Flow
Ghisellini et al. (2016)	- Eco-design - Green Design - Design for environment - Green labelling - Design for disassembly, reuse, recycling. - Design for durable products	- Green Public Procurement and Green Consumption - Enhancing the purchase of more sustainable products and services	- Cleaner production - Eco-efficiency - Resource efficiency	- Optimal product life scenario - Ensuring repair	- Product Recycling and Reuse - Law for Effective Utilization of Recyclables - Resource Conservation and Recovery Act
Sauvé et al. (2016)	- Eco-Design		- Cleaner production - Eco-efficient uses of resources	- Extend the useful life of the product - Repair - Durable long lasting good	- Maximum efficiency of usage of available resources - Waste reduction and recycling - Collecting and recycling waste
Lieder and Rashid (2016)	- Regenerative design - Design of systems with significantly lower environmental impacts - Designing products with less material	- Material criticality	- Cleaner production - Minimizes matter, energy-flow and environmental deterioration - Material efficiency	- Durable products - Comprise longer-lasting products - Extension of products lives	- Spiral-loop system - Stewardship of objects - Product recovery - Products are restored to a "like new" condition - Reuse and recycle - Recovery of products
Elia et al. (2017)	- Deliver more value from fewer materials - Increasing share of renewable and recyclable resources - Eco-design	- Material Input - Sustainable sourcing	- Efficient and sustainable use of resources - Material management framework - Less pollution through cleaner material cycles - Reducing valuable materials losses	- Increasing the value durability of products - Extension of products' lifetime - Repair	- Reducing the need for raw materials and the waste disposal - End-of-life (EoL) resource management - High-quality recycling - Minimizing incineration and landfilling - Closed loop models to recover and recycle products and materials
Geissdoerfer et al. (2017)	- Long-lasting design		- Resource efficiency - Emission and energy leakage are minimised	- Keep products, components and materials at their highest utility and value - Repair	- Waste prevention - Closed loops - Reuse and recycle
Winans et al. (2017)	- Eco-design - Materials design - Product development		- Cleaner Production - "Promotion of Cleaner Production Law" - Flow assessment - Minimize energy and raw materials use - Improving industry management		- Material flow recycling - Waste recycling post consumerism - Development of waste-based closed loops - Material circular use - Resource Recovery - Reuse and recycle

Eco-Design

The choice of the term ‘eco-design’ followed a natural process of selection. In fact, five out of the eight documents referred the concept (Su et al., 2013; Ghisellini et al., 2016; Sauvé et al., 2016; Elia et al., 2017; Winans et al., 2017). Thus, the choice of the term ‘eco-design’ seem to be the most appropriate to define the first activity that should be achieved in order to guarantee the success of a circular economy strategy.

Many authors have developed several definitions of the eco-design term (Prendeville, 2014). In general, all of these definitions follow the same pattern i.e., they refer that eco-design proactively involves addressing environmental attributes in an early stage of the product development process in order to reduce environmental impacts throughout its entire life cycle (Plouffe et al., 2011; Lidhal and Ekermann, 2013; Su et al., 2013; Dewulf, 2013; Ghisellini et al., 2016). According to Sauvé et al. (2016), “environmental gains in a specific life stage of a product should not be made to the detriment of impacts at other stages”. In circular economy, the major purpose of eco-design is to make decisions that facilitate the materials circularity (Ellen MacArthur Foundation, 2012), while enhancing the environmental value of the whole supply chain (Prendeville, 2014). The goal is to increase the utilization of recyclable and renewable resources into new products (Elia et al., 2017), deliver more value from fewer materials (Elia et al., 2017) and stimulating long-lasting design (Geissdoerfer et al., 2017).

Green Procurement

As reported by Ghisellini et al. (2016), a significant number of circular economy articles (Feng and Yan 2007; Geng and Doberstein, 2008; Liu et al. 2009; Su et al. 2013; Zhu et al. 2013) addressed the term Green Public Procurement (GPP). However, the procurement activity does not only belong to public sector responsibility but is also extensible to companies whose purchasing activity totally defines the quality of the final product (Rocca, 2016). This, the generic term ‘green-procurement’ seem to be the more appropriate to define the procurement activity of a circular economy strategy.

According to Elia et al. (2017), performing a sustainable sourcing represents a fundamental activity in a circular economy strategy. This activity mainly depends on material criticality that encompasses supply risks, environmental implications and vulnerability to supply restrictions (Lieder and Rashid, 2017). In summary, a material is considered critical “if supply is concentrated in one country or could be restricted by a few corporate interests, and because they are important economically or for national security” (Ashby, 2012). Thus, the selection the suppliers should be wisely analysed in order to guarantee the environmental consistency and the green facet of the whole value chain (Ellen MacArthur Foundation, 2012).

Cleaner Production

Similar to ‘eco-design’, the choice of the term ‘cleaner production’ also followed a natural process of selection. In fact, five out of the eight documents referred the concept (Su et al., 2013; Ghisellini et al., 2016; Sauvé et al., 2016; Lieder and Rashid, 2016; Winans et al., 2017). Thus, the choice of the term ‘cleaner production’ seem to be the most appropriate to define the third activity that should be achieved in order to guarantee the success of a circular economy strategy.

The term ‘cleaner production’ was firstly connected with circular economy by the Chinese government who have included the Cleaner Production Promotion Law into their circular economy strategy, in 2003 (Winans et al., 2017; Su et al., 2013). Cleaner production incorporates a significant number of practices that definitely boost the environmental sustainability of a company production activity (Severo et al., 2017). The use of cleaner energy and raw materials (Elia et al., 2017), the introduction of advanced techniques and equipment, the improvement of resources usage (Ghisellini et al., 2016) and the reduction of pollution in the production process (Elia et al., 2017) are just some examples of practices that cleaner production activity addresses. Commonly, this term is associated with resource efficiency (Lieder and Rashid, 2016; Geissdoerfer, 2017; Winans et al, 2017) and eco-efficiency (Sauvé et al., 2016; Ghisellini et al., 2016) and, in fact, in circular economy, one major challenge is to prevent and avoid the significant material losses. Thus, cleaner production is compulsory in circular economy and plays a prominent role to reduce environmental externalities as well as energy intensity (Su et al., 2013).

Sustained Lifespan

In the circular economy literature, many of authors defend that one key goal of circular economy strategies relies on the extension of the products lifetime (Ellen MacArthur Foundation, 2016; Ghisellini et al., 2016; Sauvé et al., 2016; Lieder and Rashid, 2016; Geissdoerfer et al., 2017). This product longevity can be achieved in two ways: by adding robustness and quality into the product features and/or by ensuring repair (Ghisellini et al., 2016; Sauvé et al., 2016; Lieder and Rashid, 2016). Although the existing consensus about the duration of products in a circular economy, there is not a term commonly used in the literature to represent that evidence. Thus, the term ‘sustained lifespan’ seem to be generic enough to embody the importance of products longevity in circular economy.

Recovery Economy

“The main focus of the circular economy, embedded in the original concept, has gradually been shifted from narrow waste recycling to broad efficient-oriented control were more areas have been covered: aside from resources and waste problems, energy efficiency and conservation, land management and soil protection, and integrated water resource management problems have also been considered as key issues.” (Su et al., 2013). However, the main point of circular economy continues to be the capitalization on material flow recycling (Winans et al., 2017) enabled by recovery strategies (Elia et al., 2017; Lieder and Rashid, 2016). In fact, this recovery process in proceeded by two major motivations: the need of minimizing the use of virgin materials and the need of minimizing the amount of discharged waste (Su et al., 2013; Geissdoerfer et al., 2017; Winans et al., 2017). In the subchapter 2.2.2., this recovery procedure was described for both, biological and technical cycle, and the relationship among the 6R-elements in a circular economy were also characterized using the literature as a basis. Thus, the selection of the term ‘recovery economy’ also followed a natural process of selection since the recovery practice represents the beginning of a wide range of practices (such as reuse, remanufacture, recycle) that can be applied in order to ensure closed-loops systems of material and energy (Ellen MacArthur Foundation, 2012; Su et al., 2013; Lieder and Rashid, 2016; Elia et al., 2017; Geissdoerfer et al., 2017).

This literature review was fundamental to understand what the key activities are, in order to ensure a successful implementation of circular economy. In fact, all these activities play an important role and if

all achievable, the underlined company strategy would definitely boost its product value chain creation as well as its environmental sustainability. After this review, it is also noticeable the relation between the activities of a traditional value chain and the activities needed in value chain based on circular economy principles. According to Rocca (2016), the main sequence of phases in a value chain is composed by the design activity, the procurement activity, the production activity, the marketing and sales activity, the use activity and the disposal activity. A value chain based on circular economy replaces these phases by environmental friendly activities, i.e., eco-design, green procurement, cleaner production, service economy, sustained lifespan and recover economy. Following this sequence of activities is indispensable the first step to achieve a green atmosphere.

2.3. Chapter Conclusion

Since the first appearance of the term 'frugal innovation' in 2010, several authors have developed research in order to provide their contribution to the definition and core characteristics of frugal products. In the majority of frugal documents, frugal innovation was defined as a sustainable innovation that boosts social and environmental improvements along its value chain. However, after a throughout literature review, it was found that the environmental pillar was poorly addressed in the frugal innovation state-of-art. Thus, performing environmental sustainability investigations on frugal innovation would certainly provide valuable and practical information to organizations and companies who are devolving or seeking to develop frugal products. These new environmental developments can represent a basis for the firms to effectively adjust their frugal value chain activities in order to incorporate some environmental sustainable practices into their daily businesses.

Circular economy emerged as a strong solution to boost environmental sustainability of value chains and is definitely a major prerequisite to stay within the planetary boundaries. Circular economy envisions a future where nothing is wasted, i.e., a future where products and components are used and reused to the maximum extent possible. The goal of circularity is to decouple global economic development from finite resource consumption.

After the literature review on circular economy, it was found that circular economy strategies rests on some important activities that are crucial to be followed in order to achieve a successful implementation: 1) eco-design; 2) conscious procurement; 3) cleaner production; 4) sustained lifespan and 5) recovery economy. These activities directly affect all the stages of a value chain but mainly enhance its environmental sustainability. In fact, although circular economy implementation positively influences economies, companies and consumers/users, the environment is the one that encompasses bigger impacts. 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. Research Methodology

The research methodology employed is a qualitative research analysis (Glaser and Strauss, 1967; Strauss and Corbin, 1998; Flick, 2009; Dillon, 2012) based on four 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 (see figure 7). As presented in the figure 7, the research methodologies employed in the present master thesis, at first place, were performed to develop the frameworks and then to validate them.

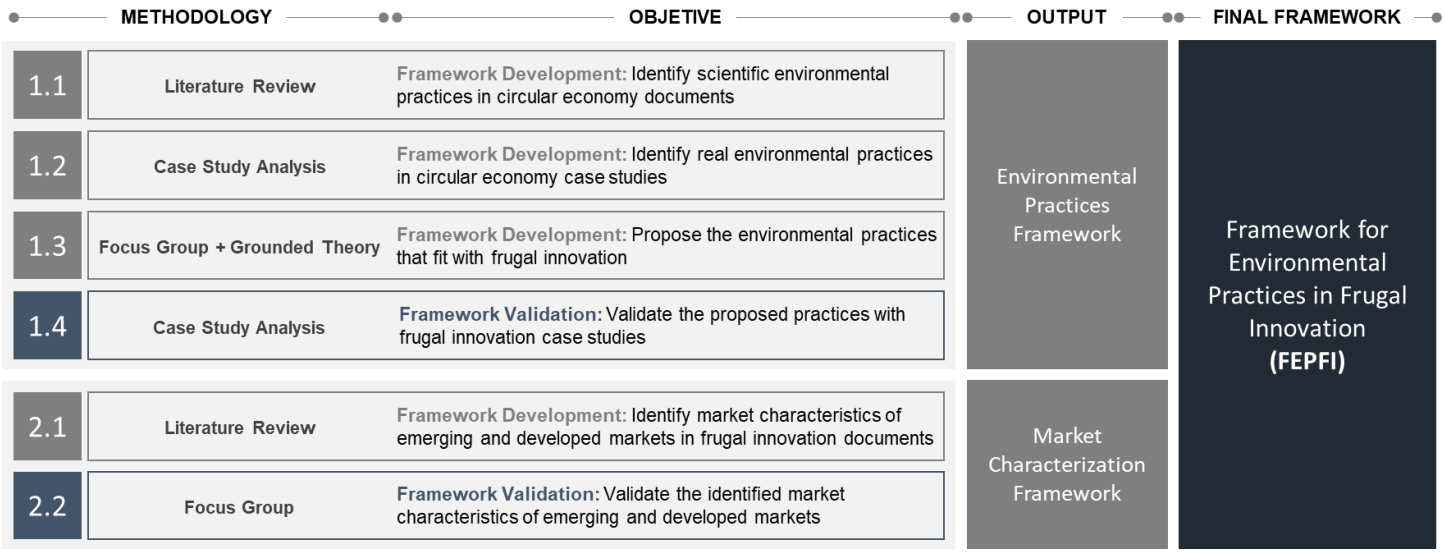


Figure 7: Framework Research Methodology

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 were frugal products are being developed (From) and targeted (To).

The present chapter describes how each methodology has been applied in the frameworks' building procedures. Section 3.1 explains, in detail, the methodology employed to obtain the Environmental Practices Framework while section 3.2. clarifies the methodology to attain the Market Characterization Framework. Finally, Section 3.3. summarizes the main findings and enumerates the next steps to be accomplished.

3.1. Environmental Practices Framework Methodology

The Environmental Practices Framework was conceived through the framework development and the framework validation. The methodologies used in both processes are following summarized.

3.1.1. Framework Development Methodology

The environmental practices were determined through the application of four main research methodologies: Literature Review, Case Study Analysis, Grounded Theory and Focus Group. The way each of these methodologies was used as well as its contribute to the present study is following explained.

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).

In order to guarantee a certain degree of correlation between the chapters of the master thesis, the documents selected to be further reviewed in this literature review match the ones analysed in the chapter 2 (see table 2). Thus, 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). It must be remembered that this list was selected based on three important elements: 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. Table 4 enumerates the documents that were reviewed in the present analysis.

Table 4: Literature Review on Circular Economy

Year	Document
2012	Ellen MacArthur Foundation
2013	Su et al.
2016	Ghisellini et al.
2016	Sauvé et al.
2016	Lieder and Rashid
2017	Elia et al.
2017	Geissdoerfer et al.
2017	Winans et al.

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. Table 5 enumerates the case studies that were considered in the analysis according to their respective sector of appliance.

Table 5: Circular Economy Case Studies

Sector	Case Study	
Built Environment	• Glass in Concrete	• Superuse Studios
Fabrics Apparel Carpets Textiles	• Better Wold Fashion • Furnishare • Desso	• Mud Jeans • Rype Office
Chemistry	• Aquafil	• Brocklesby
Information and Technology	• Floow2	
Electronic and Electrical Equipment	• Sintronics • Google • Toronto Tool Library • REEP Technologies Ltd. • GameStop	• Mazuma Mobile • Philips & Turntoo • Agency of Design • Bundles • Re-Tek
Cross Sector	• Cirkle • British Sugar plc	• Kalundborg Symbiosis • Active Disassembly
Fast Moving Consumer Goods	• Balbo Group • Takao Furuno • Toast Ale • Ecovative	• Splosh • Coca-Cola Enterprises • Brainform
Machinery and Automotive	• Renault • JLG & DLL • Riversimple • DLL Group	• Refuse Vehicle Solutions • Autocraft Drivetrain • Maersk Line • Caterpillar

Focus Group and Grounded Theory

The last methodologies employed were the focus group (Khan and Manderson, 1992; Stewart and Shamdasani, 2015) and grounded theory (Strauss and Corbin, 1998; 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 group (table 6) 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.

Table 6: Focus Group Participants (Practices)

Participants	Institution	Position	Date
Expert 1	CIROOD - Interdisciplinary Research Centre on Sustainable Development Operationalization	Scientific Coordinator for Sustainable Development	28 June 2017
Expert 2	CIRAIG - International Reference Centre for the Life Cycle of Products, Processes and Services	Researcher on sustainability, life cycle assessment, decision-making, logistics, transportation and production management	
Expert 3	CIRAIG - International Reference Centre for the Life Cycle of Products, Processes and Services	Researcher on circular economy and life cycle assessment	

Table 7 presents the proposed environmental practices and highlights the articles and companies where each practice was respectively, mentioned and implemented.

Table 7: Environmental Practices Findings

		Literature Review								Case Study Analysis																																					
		Su et al. (2013)	Ghisellini et al. (2016)	Elia et al. (2017)	Sauvé et al. (2016)	Winans et al. (2017)	Lieder and Rashid (2016)	Geissdoerfer et al. (2017)	Ellen MacArthur Foundation (2012)	Glass in Concrete	Google Data Center	Superuse Studios	Aquafil	Brocklesby	Circkle	British Sugar plc	Kalundborg Symbiosis	Active Disassembly	Sintronics	Toronto Library Tool	REEP Technologies Ltd	GameStop	Mazuma Mobile	Phillipes & Turntoo	Agency of Design	Bundles	Re-Tek	Better World Fashion	Furnishare	Desso	Mud Jeans	Rype Office	Balbo Group	Takao Furuno	Toast Ale	Ecovative	Splosh	Coca-Cola Enterprises	Brainform	FLOOW2	JLG & DLL	Riversimple	DLL Group	Refuse Vehicle Solutions	Autocraft Drivetrain Solutions	Maersk Line	Caterpillar
Eco-Design	Substitute hazardous by environmental friendly materials	x	x	x				x	x	X																										x						x					
	Incorporate biological materials		x			x			x																			x		x	x					x			x								
	Incorporate recoverable materials		x						x	x																x													x							x	x
	Incorporate recovered components	x							x	x	x	x							x												x				x								x				x
	Reduce materials usage	x	x	x	x	x	x		x									x			x																x										
	Develop energy efficient products and renewable energy consumption		x			x			x															x																		x					
	Incorporate robust materials								x																																						
	Incorporate modularity								x																																		x				
	Environmental friendly assembly								x																																						x

		Literature Review								Case Study Analysis																		
		Su et al. (2013)	Ghisellini et al. (2016)	Elia et al. (2017)	Sauvé et al. (2016)	Winans et al. (2017)	Lieder and Rashid (2016)	Geissdoerfer et al. (2017)	Ellen MacArthur Foundation (2012)	Glass in Concrete	Google Data Center	Superuse Studios	Aquafil	Brocklesby	Circkle	British Sugar plc	Kalundborg Symbiosis	Active Disassembly	Sintronics	Toronto Library Tool	REEP Technologies Ltd	GameStop	Mazuma Mobile	Phillipes & Turntoo	Agency of Design	Bundles	Re-Tek	Better World Fashion
Green Procurement	Promote supplier's environmental performance	x	x	x					x																			
Green Procurement	Cooperate with suppliers for eco-design								x																			
Green Procurement	Certify suppliers								x																			
Green Procurement	Choose suppliers by environmental criteria								x																			
Cleaner Production	Employ green chemistry		x										x	x		x												
Cleaner Production	Promote material efficiency	x		x	x	x	x	x	x																			
Cleaner Production	Promote water efficiency		x	x	x	x	x		x								x											
Cleaner Production	Promote energy efficiency and renewable energy consumption	x	x	x	x	x			x																			
Cleaner Production	Optimize land usage			x				x	x																			
Cleaner Production	Transform waste in value	x	x	x		x			x							x	x											

		Case Study Analysis (continued)																		
		Furnishare	Desso	Mud Jeans	Rype Office	Balbo Group	Takao Furuno	Toast Ale	Ecovative	Splosh	Coca-Cola Enterprises	Brainform	FLOOW2	JLG & DLL	Riversimple	DLL Group	Refuse Vehicle Solutions	Autocraft Drivetrain Solutions	Maersk Line	Caterpillar
Green Procurement	Promote supplier's environmental performance					x														
Green Procurement	Cooperate with suppliers for eco-design														x					
Green Procurement	Certify suppliers					x														
Green Procurement	Choose suppliers by environmental criteria																			
Cleaner Production	Employ green chemistry																			
Cleaner Production	Promote material efficiency														x					
Cleaner Production	Promote water efficiency																			
Cleaner Production	Promote energy efficiency and renewable energy consumption					x														
Cleaner Production	Optimize land usage						x													
Cleaner Production	Transform waste in value																			

		Literature Review								Case Study Analysis																																							
		Su et al. (2013)	Ghisellini et al. (2016)	Elia et al. (2017)	Sauvé et al. (2016)	Winans et al. (2017)	Lieder and Rashid (2016)	Geissdoerfer et al. (2017)	Ellen MacArthur Foundation (2012)	Glass in Concrete	Google Data Center	Superuse Studios	Aquafil	Brocklesby	Circkle	British Sugar plc	Kalundborg Symbiosis	Active Disassembly	Sintronics	Toronto Library Tool	REEP Technologies Ltd	GameStop	Mazuma Mobile	Phillipes & Turntoo	Agency of Design	Bundles	Re-Tek	Better World Fashion	Furnishare	Desso	Mud Jeans	Rype Office	Balbo Group	Takao Furuno	Toast Ale	Ecovative	Splosh	Coca-Cola Enterprises	Brainform	FLOOW2	JLG & DLL	Riversimple	DLL Group	Refuse Vehicle Solutions	Autocraft Drivetrain Solutions	Maersk Line	Caterpillar
Sustained lifespan	Encourage asset sharing								x											x																				x							
	Transfer product ownership	x	x	x			x		x															x		x			x	x	x	x									X	x					
	Encourage product recovery		x						x																																						
	Perform repair and maintenance services				x		x		x		x																X	x			x										x		x				x
	Encourage product usefulness and effectiveness	x							x												x		x			x		x			x							x									
Recovery Economy	Recovery system partnerships								x																													x									
	Remanufacture materials			x	x	x	x		x		x											x						x				x											x	x	X		x
	Reuse materials	x	x	x	x	x	x		x	x					x		x		x		x						x	x			x								x								
	Recycle materials	x	x	x	x	x	x	x	x	x	x		x		x		x		x			x					x				x							x	x								

3.1.2. Framework Validation Methodology

After the framework development process, a framework validation needed to be performed. The goal was to test whether the proposed environmental practices presented in the framework are being implemented in frugal innovation value chains. In order to conduct this testing process, the research methodology employed was a case study analysis.

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 chapter 2 (see table 2), where 28 out of 41 frugal innovation documents encompassed frugal innovation case studies (see column FE – Frugal Example). In fact, the content of those 28 documents, presented on table 8 was meticulously analysed and the frugal innovation case studies referred by the authors was listed.

Table 8: Literature Review on Frugal Innovation Case Studies

Year	Document
2011	Zeschky et al.
2012a	Tiwari and Herstatt
2012	Agarwal and Brem
2012	Bhatti
2012	Soydan
2013	Brem and Ivens
2013	Soni
2013	Basu et al.
2013	Rao
2013	Bhatti and Ventresca

Year	Document
2014	Tiwari and Herstatt
2014	Tiwari et al.
2014	Zeschky et al.
2015	Angot and Plé
2015	Levänen et al.
2015	Khan and Haldar
2015	Simula et al.
2016	Rosca et al.
2016	Rocca (2016)

Year	Document
2016	Pansera and Sarkar
2016	Hossain et al.
2016	Knorringa et al.
2016	Lehner and Gausemeier
2016	Hossain
2016	Khan
2016	Numminen and Lund
2016	Weyrauch and Herstatt
2016	Wohlfart et al.

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.

Table 9 presents the list of 83 frugal cases retrieved from frugal innovation literature with more than one citation. The remaining 130 products cited only once are shown in annex A.

Table 9: Frugal Innovation Case Studies

Case	#	Case	#	Case	#
Tata Nano	18	Haier's washing machine	3	Zhongxing X-Ray Machine	2
GE ECG (MAC 400)	16	Rickshaw Bank in India	3	Awaaz.De - Voice Message Board for Education	2
GE Ultrasound (LOGIQ Book)	14	Micromax's mobile phone	3	Kerala Palliative Care 4 Motorcycle-based tractor	2
Aravind Eye Care	12	Unilever's washing-powder sachets	3	ToughStuff	2
ChotuKool	12	Dachangjiang Motorcycle	3	Dacia Logan	2
Tata Swach	12	Nokia 1200	3	Bone Drill - Lunar Design	2
Mitticool	10	Nokia basic phones	3	careHPV	2
M-Pesa	9	A Little World	3	Harman's home infotainment systems	2
Jaipur Foot	9	Naandi	3	Mindray- healthcare products	2
Tata Ace	9	Kopo Kopo	3	Patient Monitoring System	2
Vortex ATMs	8	300$ House	3	Cookit - Solar Cooker International	2
Narayana Hospital	8	Bamboo Microscope	3	Liter of Light	2
Husk Power Systems	7	WE CARE Solar Suitcase	3	Kenya Ceramic Jiko (KCJ) Stove	2
Nokia 1100	7	Well Baby Bassinet	3	Ultrasound device GE Vscan	2
Aakash Tablet	7	Fetal Heart Rate Monitor	3	One Laptop per Child	2
Embrace	6	Generic Drugs	3	Avaz Speech Synthesizer	2
SELCO	6	HMI Line panel	3	IKEA furniture	2
Bharti Airtel	6	Multix Select DR machine	3	Siemens SMART line	2
Logitech mouse M125	5	Foldscope	3	KickStart's affordable and efficient pumps	2
EKO mobile phone banking	5	Electronic Voting Machine (EVM)	2	Philips's bedside patient monitoring system	2
Mettler Toledo	5	mOm	2	Conceptos Plasticos Recycled plastic houses	2
Easy Paisa	4	Nokia's 101	2	Coolar Solar energy fridge	2
Bamboo Bike	4	Unilever's Pureit	2	Columbia-Asia Healthcare	2
Oorja Stove	4	Vodafone Rs.10 pre-paid cellular phone balance	2	Wockhardt hospital - Bone Hearr Surgery	2
Siemens' Computed Tomography Scanner	4	Firefly - treat neonatal jaundice	2	Robotic Hand - Sandia National Laboratories	2
GE Lullaby baby warmer	3	BYD-Lithiumion Battery	2	Sarvajal Water ATMs	2
Mahindra & Mahindra's small tractors	3	Galanz's microwave	2	Toyola Energy Ltd "coalpot" stoves	2
Grameen Bank's microfinance	3	Haier's fridge	2		

The results of the literature review shown in table 9 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.

Relevant information of these frugal products was gathered from the scientific documents and other sources of knowledge available online (e.g. frugal products webpages) and the validation findings are presented on chapter 4 (see tables 12, 13, 14, 15 and 16).

3.2. Market Characterization Framework Methodology

The Market Characterization Framework was conceived through the framework development and the framework validation. The methodologies used in both processes are following summarized.

3.2.1. Framework Development Methodology

The frugal market characteristics were determined through the application of one main research methodology: Literature Review. The way this methodology was used as well as its contribute to the present study is following explained.

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 performed on chapter 2 (see table 2), 18 out of 41 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.

Table 10: Literature Review on Frugal Innovation Markets

Year	Document
2012	Bhatti
2012	Tiwari and Herstatt
2012	Soydan
2012	Agarwal and Brem
2012	Bound and Thornton
2013	Tiwari and Herstatt

Year	Document
2013	Kahle et al.
2013	Bhatti and Ventresca
2013	Brem and Ivens
2013	Soni
2014	Tiwari and Herstatt
2015	Simula et al.

Year	Document
2015	Radjou and Prabhu
2016	Hossain
2016	Rosca et al.
2016	Hossain et al.
2016	Tiwari
2016	Rocca

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 ad 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 (table 11) was conducted in order to gather perceptions, interpretations and opinions regarding the proposed market conditions' characteristics and consumers characteristics.

Table 11: Focus Group Participants (Market)

Participants	Institution	Position	Date
Expert 1	United Nations World Food Programme	Representative and Country Director	17 May 2017
Expert 2	IST – Instituto Superior Técnico	Researcher on frugal innovation markets	

3.3. Chapter Conclusion

The qualitative research methodology performed derived relevant information that support the building procedure of the frameworks.

In the development of the Environmental Practices Framework, 28 environmental practices were collected from 25 circular economy case studies and 8 circular economy documents. These practices were analysed based on the frugal innovation context (focus group), aggregated (grounded theory) and placed in their correspondent activity circular economy activity: Eco-design, Green Procurement, Cleaner Production, Sustained Lifespan and Recovery Economy. The proposed environmental practices were then validated through a case study analysis. During the framework validation, 213 frugal products were identified from 28 frugal innovation documents. The information retrieved from frugal innovation literature regarding these products was used to validate the proposed practices and to demonstrate that frugal innovation is already implementing the proposed circular economy practices.

In order to develop the Market Characterization Matrix, 18 frugal innovation documents were analysed through a literature review to determine the main characteristics of emerging and developed markets. Those market characteristics were then validated through a focus group methodology.

The final objective is to simply integrate the Environmental Practices Framework and the Market Characterization Framework to create the Framework for Environmental Practices in Frugal Innovation (FEPFI).

4. Environmental Practices Framework

This chapter presents the Environmental Practices Framework (figure 8) through the description of its main elements. Section 4.1. describes the five circular economy activities that compose the framework. Section 4.2. explains the proposed environmental practices where their definition, relevance and practical example are referred. Section 4.3. tests and validates the framework. Finally, Section 4.4. summarizes the findings and arouse a conclusion of the framework.

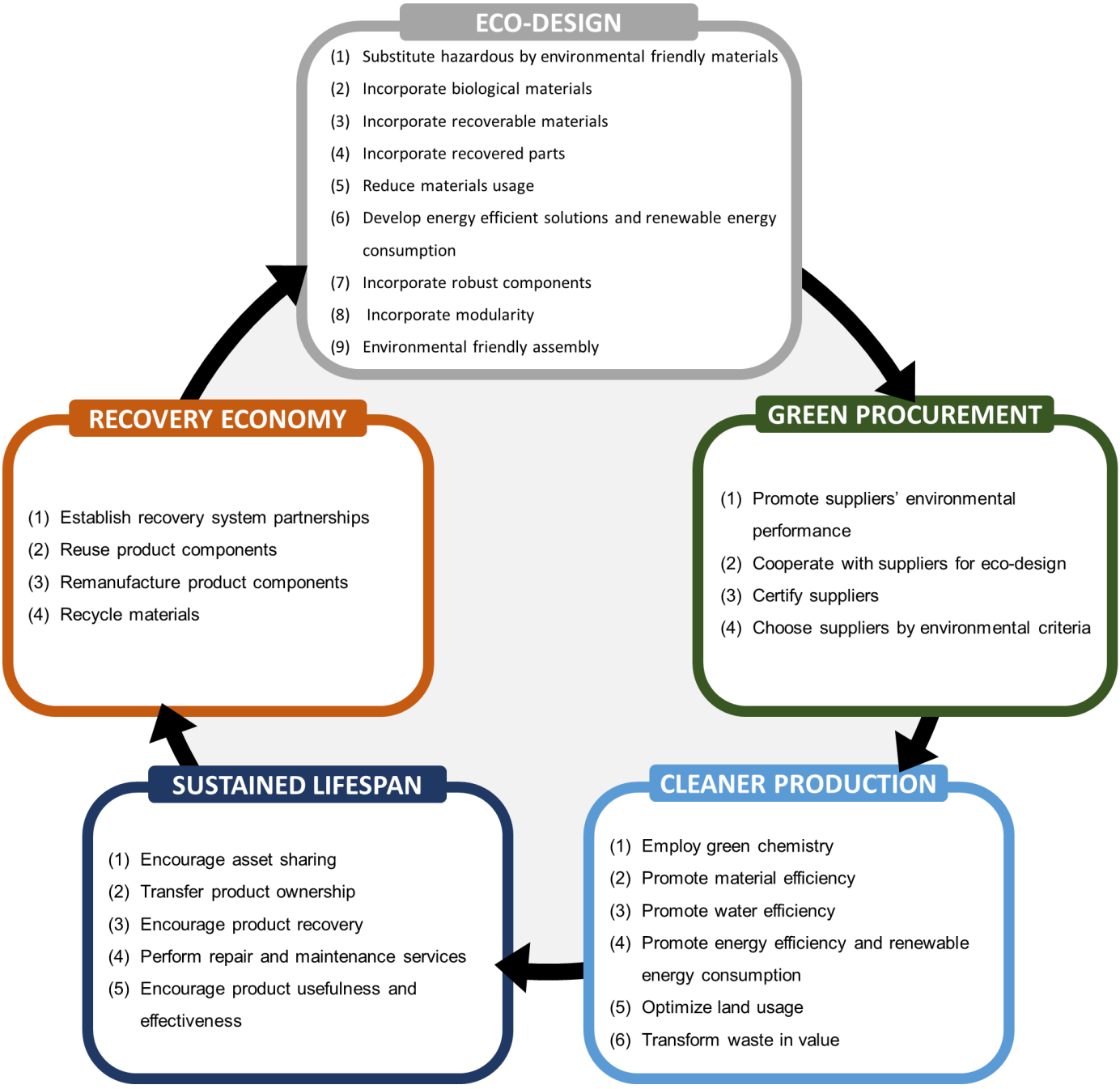


Figure 8: Environmental Practices framework

4.1. Framework Value Chain Activities

The five activities that compose the framework encompasses different processes of the value chain and it goes from conceiving the idea until recovering the product at the end of its lifecycle. Since these five activities constitute the main activities of a circular economy value chain, its visual representation must match this circular approach. The scope of each activity is described as follows:

(1) The **Eco-Design** activity encompasses all practices related to the conception and design of the product. In this activity, the characteristics and specifications of the products are defined in order to guarantee that its specific requirements such as functionality, robustness and environmental impact are fulfilled. Moreover, in the eco-design activity it is crucial to frequently perceive the whole picture of the value chain since the product architecture, the materials and the technology introduced in this phase definitely affect the other four activities of the value chain.

(2) The **Green Procurement** activity deals with the practices in charge of managing all the relationships with suppliers. It encompasses the areas of sourcing and purchasing the materials and selecting the suppliers. Well performing on this activity is crucial to guarantee a good product quality and an increased level of environmental impact of the final product.

(3) The **Cleaner Production** activity consists in the practices associated with the production process. It encompasses all the activities that enable the transformation of the raw materials into finished goods and it can go from the definition of the chemical reaction needed to produce the product components until managing the waste that remained in the end of the production cycle.

(4) The **Sustained Lifespan** activity involves two major areas: the sales and the use of the product. Regarding the sales, this activity encompasses the practices that enable to match the customer demand with company's offer. These practices are underpinned by the purchasing plan defined in the business model. It intends to achieve the sales volume objectives and to increase the companies' control over the product. Regarding the use phase, this activity encompasses the practices that manage the relationships between the company and the end-user. It consists in the practices that involve teaching and training the customers to stimulate sustainable practices that enable the increase in the usefulness. Besides this company/client proximity, this activity also comprises the practices related to maintenance and product repair since it increases the longevity of the product, and consequently, it extends its life cycle.

(5) The **Recovery Economy** activity deals with waste management practices that enable the reduction of the negative externalities associated with disposal activities. It guarantees the proper recycling of materials and the reuse and remanufacture of components. This activity is crucial in a circular value chain since it permits the closure of one cycle and the beginning of a new cycle characterized by a sustainable input of recovered materials.

4.2. Framework Value Chain Practices

The present subchapter aims at explaining the meaning of each of the proposed practices. Thus, the definition and the relevance of including them in the framework were addressed. Moreover, as a complement, a practical example containing a reviewed case study was demonstrated in order to understand how each environmental practice is being implemented in the market.

4.2.1. Eco-design practices

(1) Substitute hazardous by environmental friendly materials

Definition: Replace the hazardous materials that are continuously harming and polluting the environment by materials that can improve the well-being of the planet environment.

Relevance: Replacing the hazardous materials from the products can substantially lower the carbon footprints and minimize the exposure to potentially toxic materials. This exchange definitely increases the environmental sustainability of the components and consequently, of the final products.

Example: Glass in Concrete fully supports this idea since they intend to substitute the cement, i.e, the concrete's primary binding element that generates large amounts of CO2, by glass. By implementing this strategy, it would be possible to reduce 90 million tons of CO2 emissions (equivalent to nearly 20 million cars) as well as minimize the exposure to other heavy metals and other potentially toxic components.

(2) Incorporate biological materials

Definition: Incorporate biological materials into product components.

Relevance: Biological materials are composed by biological nutrients that are fully biodegradable. Thus, they can be returned to biosphere after its use since they poise no immediate or eventual hazard to living systems. Implementing this practice enable a faster and more effective closing of the resource loop.

Example: Evocative demonstrates how this can be successfully implemented since they produce packaging products that are made of agriculture by-products and at the end of use, the products can be composted at home.

(3) Incorporate recoverable materials

Definition: Incorporate recoverable materials, i.e., recyclable, reusable and remanufacturable materials, into product components.

Relevance: The characteristics of the components incorporated into the product strongly constrain the ability to either reuse, remanufacture and recycle the product. Thus, the inclusion of recoverable materials is essential since it enables an effective performance of recovery economy practices.

Example: Brainform, a hangers' producer, believes that their reuse opportunities would significant increase if the hangers would not have their own colours, shapes and graphics. In fact, Cerdan et al. (2009) defend that the inclusion of laminated or compound materials as well as painted, stained or

pigmented surfaces limits the potential of recycling. The incorporation of materials such as plastic, paper and glass can also be a feasible solution since their recovery systems are already established in the market. For instance, Bundles is increasingly exchanging stainless steel for plastics in their washing machines.

(4) Incorporate recovered components

Definition: Incorporate the components that were previously recovered at the end of their cycle into new products.

Relevance: The main relevance of implementing this practice is fully linked with the extraction of raw materials. In fact, by incorporating the recovered components, the demand on new resources is significantly minimized which prevents the negative expansion of the resource scarcity complications.

Example: Google Data Center places a strong effort on closing the resource loop of their value chain. Indeed, 52% of the components consumed in their machine upgrades were refurbished inventory. This happens due to the fact that once the components are in inventory, there is no distinction between refurbished and new inventory, they are both considered equivalent.

(5) Reduce materials usage

Definition: Reduce the materials usage within the product components.

Relevance: In the design phase, a focus should be place on the actual purpose of the product. The challenge of this practice rest on maintaining the functionality of the product while reducing the material input (dematerialisation) (Andrews, 2015; Bocken et al., 2015). Currently, products have extra features that do not increase the performance of the product hence they must be eliminated. The main relevance of implementing this practice is fully linked with the reduction on the demand on resource input, whether new or recovered.

Example: REEP Technologies Ltd., introduced a new circular approach towards paper use in the digital era. This start-up from Israel decided to reinvent paper in a way that the use of paper will not be reduced but each piece would be used more effectively. After some investigations, the company was aware of some available researches and technologies that pursued to remove or hide toner from paper, leaving the paper ‘as new’ and ready for re-use. With the perfect combination between a resistant and erasable paper compatible with printers and copiers and a multi-function printer device to erase the page, the same piece of paper can be reused several times. Although in an indirect way, this combination definitely reduces the materials usage since instead of using several pieces of paper, the same piece can fulfil il the same need.

(6) Develop energy efficient solutions and renewable energy consumption

Definition: Develop solutions (products/services) that boost energy efficiency during the use phase by prioritizing the selection of renewable sources of energy in order to guarantee the sustained lifespan of the product.

Relevance: According to Ellen MacArthur Foundation (2012), “renewability” plays a fundamental role in circular economy. The renewable energy must be recognized as the main energy source of a circular

economy in order to reduce the dependence on fossil energy as well as enhance the resilience of the economic systems towards oil adverse effects (increase in oil prices, lack of supply, etc) (Ghisellini et al., 2016). Moreover, developing energy efficient products also represent a decrease in the amount of energy that is consumed during the lifespan of the product.

Example: Riversimple, a UK-based car manufacturer, established the goal to create a revolutionary form of mobility in a way that the elimination of environmental impacts associated with personal transport were systematically being pursued. The focus was placed on the power source of their car solutions. Rasa, the first car developed by Riversimple, is sourced by an 8.5 kW hydrogen fuel cell, similar to the size of a small outboard engine. Besides other factors, the inherent efficiency of the fuel cell technology have contributed to an energy consumption considerably low.

(7) Incorporate robust materials

Definition: Incorporate into final product components, materials that last in time and endure wear.

Relevance: Circular economy envisions the occurrence of successive circular resource loops. However, if each loop could be slowed down, the rush to initiate their recovery as well as the necessity to extract raw materials to produce new products would be reduced. Thus, incorporating robust materials into product components can certainly empower the extension of products lifespan and durability.

(8) Incorporate modularity

Definition: Develop products that are composed by different and independent modules.

Relevance: Modularity is essential to enable the user to replace one part of a product when it require a repair or/and an upgrade, preventing the need to replace the entire device. This practice also performs an important role in the recovery of the product since the disassembly process can be operated with higher effectiveness and lower difficulties.

Example: Agency of Design recognized another relevant benefit of decomposing products into modules. They have selected a common household good, the toaster, to test different design solutions and examine their implications in circular economy. In one of their strategies, they have developed a toaster in modules where each module was designed to fit through a UK letterbox. This would definitely make product delivery and return more convenient for the user. Besides, whenever a module fails, a new unit can easily be delivered and placed into the toaster.

(9) Environmental friendly assembly

Definition: Environmental friendly assemble of the modules in a way the durability of the product is extended, and the disassembly process is facilitated.

Relevance: There are a considerable number of practices that can be implemented in order to guarantee the environmental friendliness of the assembly strategy. Placing the modular components that have a greater predisposition to damage (less robust components) in an interior area of the product or allocating the components that require frequent repairs and/or upgrades in an easy to reach area represent some of the good examples that can be employed.

Example: Among the reviewed case studies, Caterpillar recognized another relevant benefit of assembling the modular components in an environmental-friendly manner. Their current strategy rest on remanufacturing parts of their heavy machinery solutions. Thus, they have implemented some measures into the design phase in order to facilitate the disassembly process and consequently, facilitate the remanufacturing of the components. One of their most well-known strategies involves an engine block with a removable sleeve in the cylinder bore. The time needed for disassembling removable sleeves and reversible joints is much shorter and the complications and required tools are significantly less.

4.2.2. Green Procurement Practices

(1) Promote suppliers' environmental performance

Definition: Stimulate the suppliers in adopting measures that improve their environmental sustainability.

Relevance: The coordination between stakeholders along the value chain is vital to ensure the value creation maximization as well as the proper functioning of all process in order to ensure the accomplishment of the deadlines. Besides this coordination, sharing knowledge between actors can definitely determine the success of a business model. Thus, stimulating suppliers in implementing practices that can improve their environmental performance is essential not only to the whole value chain due to the increase in material and energy efficiency but also to the surrounding environment who totally benefits with these less damaging and polluting practices.

(2) Cooperate with suppliers for eco-design

Definition: Involve the suppliers in leveraging the implementation of eco-design solutions.

Relevance: In most cases, the design of a product can be seen as its own DNA. In fact, the product physical properties can differentiate the product from the ones developed by the competitors. Thus, involving the suppliers in the design phase can leverage the implementation of better solutions. In fact, coordinating efforts with suppliers can ensure that the standards are met or even exceeded. A product is composed by different parts and when those parts met the originally proposed requirements, the product will boost their quality, durability and performance.

(3) Certify suppliers

Definition: Cooperate with suppliers in order to employ an environmental management system that meet the legal requirements and ISO standards.

Relevance: All environmental management systems help organizations on identifying, managing, monitoring and controlling their environmental issues in a holistic manner (International Organization for Standardization, 2015). Ensuring that suppliers have an environmental management system in compliance with legal requirement and ISO standards enables an improved environmental performance through more efficient use of resources and reduction of waste which empowers their competitive advantage and gains the trust of stakeholders.

(4) Choose suppliers by environmental criteria

Definition: Favour suppliers that meet or exceed regulatory standards for environmental impacts and comply to ISO 14001 management systems.

Relevance: Once again, having suppliers who have an environmental management system that is in compliance with legal requirement and ISO standards enables a more efficient use of resources and reduction in waste. This improved environmental performance empowers organizations' competitive advantage and increases the trust of stakeholders. Thus, whenever possible, suppliers must be selected by their performance and the ones that are well-beavering in their environmental procedures must be preferred.

4.2.3. Cleaner Production Practices

(1) Employ green chemistry

Definition: Define the chemical reactions that guarantee the efficient use of the resources, the elimination of waste and the avoidance of the use of toxic and/or hazardous reagents and solvents in the production and application of chemical products (Shelton, 2016).

Relevance: Green chemistry encompasses new ways of producing new chemical products (preferably, renewable and non-toxically) in a way that the yield of the chemical reactions is maximized and the production of by-products is reduced. If there is no possibility to eliminate the total amount of by-products, they must be previously allocated to a future utilization in order to ensure that no material is wasted.

Example: Brocklesby, a leading food waste recycling company whose expertise lies in recycling edible oils and food fats for a diverse range of end user industry sectors including biofuels and energy generation, started to work closely with a green chemistry group from the University of York. Their goal was to try to implement some green chemistry techniques into their recycling process to find better uses for some of the waste stream that they were dealing with.

(2) Promote material efficiency

Definition: Minimize the amount of wasted materials in the production phase.

Relevance: The relevance adjacent to this practice rest on a clear premise: reduce the total amount of waste generated along the value chain. In this particular case, a focus is placed on the production phase where scrap materials should be minimized. During the production phase, there are several potential sources of material losses hence implementing a system able to increase the level of material efficiency would not only reduce the total amount of waste generated but also the negative externalities associated with the polluting disposal activities.

(3) Promote water efficiency

Definition: Minimize the amount of water wasted in the production phase.

Relevance: The water is an indispensable and precious resource not only to human health but also to the environment well-being. Unfortunately, the water is being excessively used under non-efficient

procedures which puts in danger the quantity available to fulfil the basic requirements of the world population. Due to this increasing in the water scarcity level, companies must undertake and implement water integration processes to guarantee their future sustainable competitive advantage.

Example: Kalundborg Symbiosis has become a guidebook example of effective resource saving materials in industrial production. They were the first industrial symbiosis well-functioning in the world and through their outstanding performance they were able to save 3 million cubic metres of water.

(4) Promote energy efficiency and renewable energy consumption

Definition: Reduce the amount of energy consumed in the production phase by selecting renewable sources of energy.

Relevance: The use of renewable energy must be extensible to all value chain activities. Thus, the production phase is not exception and all sustainable sources of energy must be incorporated in all manufacturing steps in order to achieve a high level of energy efficiency. An organization can have plenty of benefits by empowering the transition towards renewable sources of energy and it definitely represent a significant environmental opportunity. Among the benefits, the reduction on the greenhouse gas emissions establishes an important reduction on the number of negative externalities since it can lower the impacts of climate change at a local and consequently global level.

Example: Balbo Group is a perfect example of how the employment of energy efficient practices can benefit both, the company and the society. Balbo Group, a Brazilian organic sugarcane grower, produces 100% of the energy it needs to process around 6 million tonnes of sugarcane per year. This energy is produced in thermoelectric power plants that run on sugarcane bagasse, i.e., a residue left after the extraction of juice of the sugarcane. Besides the energy self-sufficiency, the company has also generated enough extra power to supply a city of almost half million of inhabitants.

(5) Optimize land usage

Definition: Increase the efficiency of land usage in order to eliminate the unnecessary spaces and boost productivity.

Description: Identically to the abovementioned resources, i.e., materials, water and energy, the land is undoubtedly an asset that must be taken into consideration during the production phase. By optimizing the land that is available to perform the production activities, a set of benefits arise. Generally, land-efficient factories are smaller and have a policy of clearing out the empty and unnecessary spaces that do not bring value to the daily activity of a factory. This conceivable reduction can positively influence the excess amount of time spent by the non-efficient paths of resources transportation and employee movements. Other procedure that can be followed to achieve a good level of land-efficiency can be installing removable and ambulatory machines instead of fixed machines. This implies that the same piece of land can be occupied by different tangible assets which empowers the efficiency of that factory space.

Example: Among the reviewed case studies, Takao Furuno, a Japanese rice producer, raised this idea into a new level and have implemented, into their small-scale farm, a symbiotic production where in their

6-acre farm they synergistically combined the growth of rice with the production of a variety of other food derivatives. This symbiotic production enabled a rice yield that exceeds industrial rice systems' harvests by 20-50% and Takao Furuno sometimes achieve the gross income of a typical 600-acre rice farm in Texas.

(6) Transform waste in value

Definition: Collect the materials that were wasted in the production phase (including by-products, co-products, material scraps, wasted water, etc) and transform them in a way that they can be employed as an input of another processes or activities.

Relevance: The relevance adjacent to this practice rest on a clear premise: reduce the total amount of waste generated along the value chain. In the production phase, there are several and significant sources of waste that can be originated in the processing phase of materials (material scraps, wasted water, etc) or even through the chemical reaction by itself (by-products). Thus, finding ways of reducing those amounts of waste by transforming them into potential inputs of other processes or activities is vital.

Example: British Sugar plc, an UK-based sugar producer, is performing extraordinarily in implementing this practice since they only create 200 grams of waste per every tonne of sugar produced. The way they achieve these numbers is astonishing: 1) The soil and stone removed during the cleaning process of the beets, is transformed into aggregate and topsoil. The aggregate is marketed for civil engineering, road-building and construction projects while the topsoil is sold into the landscaping and amenity industries; 2) After the washing and slicing process, the sugar beet is purified. The lime used to purify is turned into LimeX, another saleable product commonly used by growers to correct soil acidification; 3) After extracting the sugar from sugar beet, the beet pulp is pressed to generate thousands of tonnes of high quality animal feed that are therefore supplied to the livestock industry. Among others, the previous examples describe some of the proceedings that are being employed by British Sugar plc.

4.2.4. Sustained Lifespan Practices

(1) Encourage asset sharing

Definition: Allow that different individuals can have access to the use of the same product and/or service.

Relevance: By encouraging asset sharing, the number of products that are produced to fulfil the needs of each individual is significantly reduced since the same product unit can satisfy more than one consumer or family. This practice is easier to implement in products that do not require continuous use and are not that vital in the daily routine of an individual. Asset sharing can be achieved through the development of peer-to-peer models where the products in the platform are available to whom visits the space or it can be accomplished by encouraging the consumers to rent their own products.

Example: Toronto Tool Library, have developed a peer-to-peer platform where the main goal was to create a library where Torontonians could borrow the objects that they desired instead of buying them. It all began with the first tools objects such as drills, screwdrivers and tape measure. However, this was

extensible to other type of matters such as sport equipment, toys, camping equipment, board games and house party supplies. Instead of buying these objects that during their lifetime are used for only few minutes (for instance, one average drill is just used for 13 minutes in its lifetime), the users can pay an annual membership fee of $50 and can borrow all the items available in the library as many times as required.

(2) Transfer product ownership

Definition: Transfer product ownership from consumers to manufacturers and retailers.

Relevance: By retaining product ownership, the company can place a strong focus on product longevity, reliability and reusability. The underlying idea is to offer products as a service where leasing and renting strategies enable an active emphasis on the utilization of the product. This activity is mutually beneficial for the consumer and for the company. Consumers only pay for the service they require and use which regularly is a product that lasts and manufacturers can retain greater control over their products which enables better maintenance and recovery. In fact, implementing this practice would definitely empower the ability of the company to manage the collected goods and to develop a well-established recovery system.

Example: Furnishare found this practice an excellent option to be incorporated in their business model. In their purpose, customers pay to have access to high-quality furniture rather than owning it directly. The first step of the process starts when someone with an unwanted item of furniture contacts Furnishare who reviews and collects the piece from the present owner. Then, the item is placed on the online platform where potential consumers can view and lease it. It should be pointed out that traditional rental stores claim nine times more the price Furnishare offers.

(3) Encourage product recovery

Definition: Boost consumer's responsibility towards the return of products for recovery purposes.

Relevance: Through the upsurge of public awareness regarding the importance of the recovery process in our ecosystem, the number of products that are returned by consumers can definitely increase. Instead of moving directly to landfill and incineration, companies have the possibility to recover these products through remanufacturing, reuse and recycling practices.

Example: Mud Jeans stressed out the importance of encouraging product recovery and have adapted their own business model in order to increase the end-of-life return rate. In fact, this apparel manufacturer offers financial incentives to the return items.

(4) Perform repair and maintenance services

Definition: Ensure that companies are performing repair and maintenance services in order to guarantee that the products are fixed when some component fails or requires an upgrade and to extend product longevity.

Relevance: By repairing the decayed or damaged component, the product is restored to a good condition which enables an increase in the longevity of the product as a whole. Certainly, that the

assurances are generally limited to the repaired component. However, when other part requires repair or upgrade the company should immediately act to avoid the complete inactivation of the product.

Example: Caterpillar recognized the importance of having consistence knowledge about the components in order to intercept products before they break. Thus, they have developed a digital technology which enables to monitor the general status of the items. This knowledge allowed them to perform repair and maintenance services as soon as the components require which assuredly extends its lifespan.

(5) Encourage product usefulness and effectiveness

Definition: Promote the correct use of the product near customers by appealing for the demand-side moderation in avoiding overconsumption practices and in being carefully when managing the products.

Relevance: Encouraging product usefulness and effectiveness guarantees an increase on the customers' knowledge about the product. By teaching them which are the practices that should be followed, the durability of the product can be safeguarded, and the overconsumption of energy and materials can be reduced.

Example: REEP Technologies Ltd, reinvented the concept of using paper and instead of reducing its use by incorporating digital solutions, they placed a strong focus on how consumers can use each piece more effectively. Thus, the company designed a resistant and erasable paper and a multi-function printer device that enables that erasure due to their toner removal laser. Instead of having one sheet serving only one employee, three reams of paper can serve, on average, 35 employees per day and each sheet can be reused up to 20 times over. REEP Technologies Ltd constantly encourages their customers on making an useful and effectiveness use of their products.

4.2.5. Recovery Economy Practices

(1) Establish recovery system partnerships

Definition: Build strong relationships with recovery partners who are experts in the collection, transportation and treatment of waste whether for reusing, remanufacturing or recycling purpose.

Relevance: Establishing recovery system partnerships is crucial when a company do not have the expertise, infrastructure and capital to venture into this complex area or just when the organization prefers to focus on other practices of the value chain. In general, these relationships also symbolize an ensured and excellent performance in managing and treating the waste. These recovery partners can be in charge of collecting, dismantling, cleaning and transporting the no longer used products and transport them to the company factories where the goods are either remanufactured or subsequently reused. The components that are not in the desired condition to serve these previous two solutions are sent to recycling facilities to be transformed into possible new material inputs. The goal of establishing these partnerships is to reduce the amount of waste that is constantly being sent to landfill or incineration.

Example: Among the reviewed case studies, Coca-Cola Enterprise has invested €13 million in two strategic recycling partnerships that operate in Great Britain and France. Continuum, the joint venture

in Great Britain, has recently reached the milestone of 1 billion bottles reprocessed since its opening in 2012. And Infineo, the joint venture operating in France, is today the first national education center of circular economy that hosts more than 5,000 students per year due to their outstanding practices in the full process of recycling.

(2) Reuse product components

Definition: Use again the products and components that are in good condition and were not sent to be wasted into new life-cycles.

Relevance: There are two ways of reusing products. The first option totally depends on the condition of the product as a whole, i.e., if the product, at the end of their first cycle, is in good condition, the whole product can be sent to a retailer to be sold again directly to a new customer, at a lower price. The second way lean on the status of the components as individual items, i.e., if the product, as a whole, is under the desired level of acceptability but there are some components that are in a like-new or adequate condition, they must be reused and incorporated into new products. Both alternatives are truly relevant to achieve some environmental goals erstwhile defined, particularly, the reduction of the total amount of waste generated and extension of the durability of the product.

Example: Better World Fashion identifies reusability as its core business. They produce jackets from reused leather that is collected from NGOs across Denmark. The jackets are as different as the customers since by using reused leather the jackets will never be identical. Better World Fashion offers a range of uniqueness products but, above all, avoids that like-new pieces of clothing end up in landfill and incineration centers. A recent research established that 93% of the clothes in the world are thrown up even though they can be reused and recycled. In fact, 80% of all discarded apparel still have around two thirds of their life left (Better Worlds Fashion, 2017).

(3) Remanufacture components

Definition: Restore the products that were recovered at the end of their first cycle and are not in a good condition to be reused and combine them with new parts in order to manufacture a new product.

Relevance: Like the reuse practice, remanufacturing materials have a positive and active impact in the optimization of the resource yields. In fact, it enables the lifespan extension of the product since the components are recovered and incorporated into a new cycle through the launch of new products in the market. Besides this durability extension, by remanufacturing components, the devastating externalities associated with the disposal activities are significantly reduced. Instead of ending up in disposal centers, the components are reintegrated and practically restored into their original state.

Example: GameStop, originally a software and video games retailer, has extended their business activity into a new area of interest. They have started to invest in the remanufacturing and refurbishing of all kinds of electronics and currently, they present themselves as the largest refurbisher of electronics in the world. The goal of GameStop is to return the products to their original factory condition, without upgrades or downgrades, and if necessity they can also erase all the data present on the devices through an in-depth process.

(4) Recycle materials

Definition: Convert the materials of the components, that are not in a good or acceptable condition to be either reused or remanufactured, into useful raw-materials.

Relevance: In a circular economy, recycling is vital to guarantee that the materials that were not recovered for reuse and remanufacture purposes, have a different destiny than landfill and incineration centers. In fact, recycling offers the opportunity to benefit from still usable resources and enables the reduction of the virgin materials consumption. Other relevance adjacent to this practice comprehends the significant decrease on the quantities of waste that are constantly sent to be disposed and subsequently, the reduction on environmental impact.

Example: Among the reviewed case studies, Cirkle current business model is a perfect example of how optimizing the non-so effective practices of a company can definitely improve the well-being of the surrounding environment. The company started to provide a delivery service and to source fresh ingredients from their partner suppliers and local shops around Belgium. Six months after the company initiates their activity, they recognized that their fleet of vans were returning fully empty and with a lot of space available. Thus, they introduced a return logistics service where more than 20 streams of items were collected including batteries, metal hangers, pens, toys, glasses, baby stuff, vegetable oil, etc. This opportunity has brought a hand full of convenience to the consumers but above all, it allowed that the company could redistribute these items to centers of other recovery companies where recycling activities daily take place. In fact, this business model is still being a success. Cirkle recycles more waste than they actually create and 100% of the money received from the recycling process goes directly to charities.

4.3. Framework Validation

The present subchapter aims at testing and validating the Environmental Practices Framework. For this purpose, the case study analysis was the methodology employed and it resulted on the collection of 213 frugal innovation case studies. The relevant information displayed on the reviewed sources of knowledge reviewed was gathered and previously analysed. Tables 12, 13, 14, 15 and 16 sum up the main findings.

Table 12a: 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) (M-KOPA, 2011).
Incorporate biological materials	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 (ModRoof, 2015).
Incorporate recoverable 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, 2013; 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; Renaul Dacia, 2008).
Incorporate recovered components	Liter of Light	Liter of Light is a global and grassroot 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; Liter of Light, 2018). Energy poverty keeps more than a ¼ 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 (Liter of Light, 2018).

Table 12b: Eco-Design Practices Validation (Cont.)

Eco-Design Practices	Validating Frugal Solution	Motive of Validation
Reduce materials usage	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 constrains (Kumar and Puranam, 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).
Develop energy efficient solutions and renewable energy consumption	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).
Incorporate robust materials	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 modularity	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 Haldar, 2015; Hossain et al., 2016).
Environmental friendly assembly	Tata Swach 	Tata Swach, 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).

Table 13: Green Procurement Practices Validation

Green Procurement Practices	Validating Product	Motive of Validation
Promote suppliers' environmental performance	Ghana Bamboo Bikes 	Ghana Bamboo Bikes, multipurpose affordable and high-quality bamboo bicycles, (Rosca et al, 2016), were developed by engineers from Columbia University aiming at introducing a sustainable form of transportation in Africa (Ghana Bamboo Bike, 2011). In order to promote the environmental performance of their procurement activity, the company vertically integrated its own bamboo plantation to avoid resource scarcity and ensure material availability (Rocca, 2016).
Cooperate with suppliers for eco-design	Tata Nano 	Tata Nano, launched in India in 2009, is considered the cheapest car of the world with an initial market introduction price of US$ 2,000 (Bhatti, 2012). Tata Group decided to integrate suppliers very early in the product development (Tiwari and Herstatt 2012) in order to increase Nano performance and affordability. The cooperation was well succeeded and 70-80% of the invited suppliers have contributed their own ideas for this project (Tiwari and Herstatt 2012).
Certify suppliers	Glatt Stove 	Glatt Stove is a portable stove that functions with environmental friendly fuel (emissions of the liquid fuel are 7 ppm vs 750000 ppm generated by wood burning) (Rocca, 2016). In order to promote the environmental sustainability of their procurement activity, La estufita, the company that produces the stoves cooperatively guarantees, that their suppliers are certified regarding environmental protection (Rocca, 2016).
Choose suppliers by environmental criteria	Jibu 	Jibu is a distribution network that provides affordable (1$ for 20L), convenient and high-quality drinking water (Jibu, 2018a). With more than 45 million liters of water distributed in 4 African countries, Jibu's plastic bottles are sealed with a government quality certification. This can be achieved since Jibu selected 2 African suppliers that guarantee robust and certified plastic bottles (Rocca, 2016).

Table 14a: Cleaner Production Practices Validation

Cleaner Production Practices	Validating Product	Motive of Validation
Employ green chemistry	Pureit 	Pureit is a Unilever's household water purifier (Hossain, 2016) that does not require electricity or running water to work. The technology of the water filtration system consists of a four-stage purification process (Levänen et al., 2015). The third stage includes a chlorine dispenser ("Germkill Kit") hence the last stage is composed by a carbon polisher that removes the excess of chlorine and chlorination by-products (Levänen et al., 2015).
Promote material efficiency	EVM 	Electronic Voting Machines (EVMs) constitute a simple electronic device used to record votes. In India, the first prototype was developed in 1979 by government institutions in collaboration with public-sector enterprises. In 2004, during the national elections, EVMs were used throughout the country and were able to save about 8,000 tons of paper (equivalent to 150,000 trees) (Tiwari and Herstatt, 2012).
Promote water efficiency	Tata Swach 	Tata Swach, the water purification system, was firstly tested in the Tata innovation center in Pune. During the scale-up and to leverage synergies, the mass manufacturing of the product was conducted in an existing manufacturing plant in Haldia (Tata Swach, 2017). "Haldia meets its water requirement through the state Public Health Engineering Department's supply of treated river water" and by recycling most of the effluent generated from phosphoric acid plants, the plant can moderate freshwater withdrawal (Tata Swach, 2017).
Promote energy efficiency and renewable energy consumption	Tata Ace 	Tata Ace is a small commercial vehicle targeted for the segment of professional truck-drivers and it was launched in 2005 with a price tag of $5,000 (Tiwari and Herstatt, 2012). The vehicle is produced in a manufacturing plant in Pantnagar, India. As stated in the sustainability report of the Tata Group (Tata Ace, 2017), an important energy conservation initiative was developed in Pantnagar plant. 1325 energy efficient LED lights were installed in shop floor areas and vehicle storage pads which has led to energy savings of 3292.2 GJ and 749.89 tCO2 emission avoidance (Tata Ace, 2017).

Table 14b: Cleaner Production Practices Validation (Cont.)

Cleaner Production	Validating Product	Motive of Validation
Optimize land usage	Lotus Food Rice	Lotus Food Rice is an “organic, heirloom and fair-trade specialty rice grown on family farms with respect for women, water, soils and communities” (Lotus Food, 2017). The Lotus Food company by pursuing smart production innovation and better growing practices developed the more crop per drop growing process called “System of Rice Intensification”. This system enables faster wedding, soil aeration and health, extensive root systems which all contribute to higher yields (Lotus Food, 2017).
Transform waste in value	Agricultural Biomass Gasifier 	Agricultural Biomass Gasifier is a biomass fuel energy generator system used to water the fields (Pansera and Sarkar, 2016). The engine is able to run using the gas from farm waste. In fact, any agricultural bio-waste can be recycled and used in the machine such as cotton waste, coconut shells, rice husk, bamboo, etc. (Pansera and Sarkar, 2016).

Table 15: Sustained Lifespan Practices Validation

Sustained Lifespan Practices	Validating Product	Motive of Validation
Encourage asset sharing	Nokia 1100 	Nokia 1100, similarly to the other Nokia’s cell phones, uses ethnographic techniques to understand the way people use mobile phones in emerging markets (Soydan, 2012). To target those needs, Nokia 1100, include multiple address books for several users since different people in a family share a handset (Soydan, 2012; Angot and Plé, 2015).
Transfer product ownership	-	-
Encourage product recovery	SELCO 	SELCO is a solar energy system integrator that’s consists of four compact florescent lights whose electricity is generated by a small photovoltaic module (Levänen et al., 2015). SELCO offer users the option of including the cost of a second battery. This encourages users to return the spent batteries to SELCO for recycling (SELCO, 2018).
Perform repair and maintenance services	IluMéxico 	Ilu México is a photo-voltaic solar energy system that offers lighting and electrification for households or companies (Ilu México, 2015) in marginalized rural areas (Rocca, 2016). In order to guarantee after-sale support, the company provide technical assistance and maintenance services through regional distribution centers and representatives (Rocca, 2016).
Encourage product usefulness and effectiveness	Mozambike 	Mozambike is an affordable, gender friendly and locally assembled bicycle whose design has been modified over the course of years to meet the needs of Mozambicans in rural areas (Mozambikes, 2016). In order to encourage product usefulness, the company provides training including workshops for female riders and road safety campaigns (Rocca, 2016).

Table 16: Recovery Economy Practices Validation

Recovery Economy Practices	Validating Product	Motive of Validation
Establish recovery system partnerships	Dacia Logan 	Dacia Logan, the affordable and robust car launched by Renault in 2004, has 95% of recyclable components. In order to bolster the car recycling services, a relevant recovery partnership was established with Sita, a waste management firm (Dacia Logan, 2008). The joint venture was established due to the increasing regulatory pressure that car markets are facing to improve their take back services and the recyclability of their vehicles (EU's end-of life vehicle directive).
Reuse product components	Jibu 	Jibu, the distribution network that provides drinking water to 4 African countries (Jibu, 2018a), adapted their business model in order to recover the plastic bottles from their customers. Consumers pay a bottle deposit and then exchange an empty bottle for a full bottle. All the recovered bottles are reused from Jibu and this model foster customer loyalty since consumers only pay for the water, not for the plastic waste (Jibu, 2018b).
Remanufacture product components	Global Cycle Solutions 	Global Cycle Solutions distribute affordable, accessible and appropriate solar lighting systems to local villagers in Tanzania (Global Cycle Solutions, 2018). The incorporated components are durable to avoid quick obsolescence (e.g. LED lamp rated for 10 years). However, due to the harsh conditions in Tanzania some components may be damaged. Thus, the company collects the broken products to perform refurbishment/remanufacture activities (Rocca, 2016).
Recycle materials	Glatt Stove 	Glatt Stove, the portable stove that functions with environmental friendly fuel, was designed to be easily disassembled. This facilitates the product recovery process and boost a positive impact in recycling activity: aluminium is 100% recycled and plastic 60% recycled (Rocca, 2016).

Based on the validation process performed and on the information displayed on tables 12, 13, 14, 15 and 16, 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 (Rocca, 2016), Husk Power (Basu et al., 2013; Hossain, 2016; Numminen and Lund, 2016;); Agricultural Biomass Gasifier (Pansera and Sarkar, 2016); Ghana Bamboo Bikes (Rao, 2013; Hossain, 2016; Rosca et al., 2016; Rocca, 2016); Bamboo Microscope (Rao, 2013; Hossain, 2016; Rosca et al., 2016).
- Develop energy efficient solutions and energy consumption: Mitticool (Levänen et al., 2015; Numminen and Lund, 2016; Weyrauch and Herstatt, 2016; Lehner and Gausemeier, 2016); ChotuKool (Tiwari and Herstatt, 2012; Soni, 2013; Khan and Haldar, 2015; Hossain et al., 2016); Vortex ATMs (Tiwari and Herstatt, 2012; Levänen et al., 2015; Hossain, 2016; Khan, 2016); Micromax (Hossain, 2016; Levänen et al., 2015; Rosca et al., 2016).
- Incorporate robust materials: ToughStuff (Basu et al., 2013; Hossain, 2016), Nokia 1100 (Soni, 2013; Simula et al., 2015; Numminen and Lund, 2016); MAC 400 (Agarwal and Brem, 2012; Basu et al., 2013; Tiwari et al., 2014).

(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.

4.4. Environmental Practices Framework Conclusions

The methodology employed to develop the Environmental Practices Framework resulted on 5 main circular economy activities that combined total 28 environmental practices. In order to understand those two elements of the framework, the scope of each value chain activity was described and the proposed environmental practices were explained. The description of the value chain activities was performed to highlight that the framework encompasses different processes of the value chain that goes from conceiving the idea until recovering the product at the end of its lifecycle. This analysis also intends to demonstrate the circular relation between activities (after the recovery of components, they are integrated in a new cycle). Therefore, the environmental practices were explained to elucidate the reader about the meaning behind each practice. In order to do so, the definition and relevance of including them in the framework as well as a practical example of a circular economy case study were addressed.

Following the activities description, a validation was carried out to assess if the proposed practices are being implemented in frugal innovation case studies. This validating process leverage some relevant concluding topics. First, there is an undeniable existing link between frugal innovation and the environmental practices which supports that frugal innovation supply chains are environmental sustainable. Second, the environmental practices proposed on the framework revealed to be accurate since they demonstrate to be feasible and suitable to the frugal innovation context.

5. Market Characterization Framework

This chapter presents the Market Characterization Framework. Section 5.1. describes the market condition characteristics and consumers' characteristics in emerging and developed markets. Section 5.2. sums up the evidences acquired along the research as well as subsequent conclusions.

5.1. Framework Characteristics

The market characterization framework (figure 9) 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 retrieve 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 threat to the success and viability of frugal innovation within the market. Figure 9 presents the market characterization framework with the drivers in green colour and the barriers in red colour.

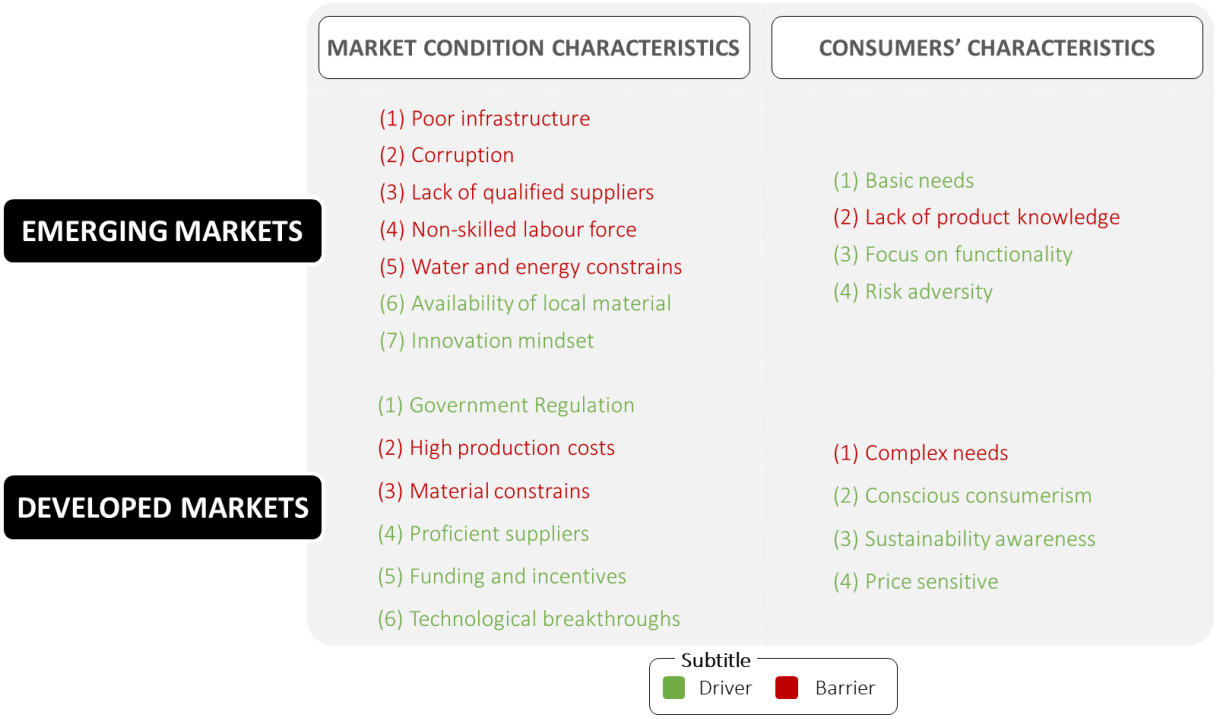


Figure 9: Market Characterization Framework

5.1.1. Market Conditions in Emerging Markets

There are seven main market characteristics that can condition the future and prosperity of several businesses in emerging markets:

(1) **Poor infrastructure:** The penurious nature of world class infrastructures in emerging economies is holding back its growth and development (Garner et al., 2008; George et. al., 2012; Bhatti, 2012; Sun et. al., 2016; DNA, 2016; Knorringa et al., 2016). Although some efforts are being made to overcome this last mile challenge, there is still an infrastructure deficit in terms of quantity and quality (Soydan, 2012; Euromonitor International 2014; Kondis and Stehli, 2014; Numminen and Lund, 2016;). In the majority of emerging countries, infrastructures related with the transport services, urbanization, production facilities and recovery aspects are far behind from the quality they need to be aligned with the eagerness of achieving a global world (Euromonitor International 2014).

(2) **Corruption:** Among other governmental issues, the corruption is excessively incorporated in emerging markets (Soydan, 2012; Bound and Thornton, 2012; United Nations Development Programme, 2014). The high rates of corruption in emerging countries is creating a severe and unstable economic situation (Transparency International, 2014). The misuse of power, whether in form of money or authority, is bringing illegalities and dishonesties to an unsustainable level and is directly affecting the entire society of the corruptive nations (Investopedia, 2015). In countries with high corruption levels, the average income is three times lower than in countries with lower levels of corruption (The World Bank Group, 2017). Additionally, corruption also discourages poor people from accessing health services which negatively affects health outcomes such as infant mortality (The World Bank Group, 2017). The financial risk associated with corruption is also an important issue that companies must lead with when they are producing in emerging economies (Rahdari and Rostamy, 2015). There is always a high risk of not receiving their payments and this uncertainty is pushing multinationals to end up with their activities in emerging markets.

(3) **Lack of qualified suppliers**: In emerging markets, suppliers have a crucial role in achieving the desired level of business success and prosperity (Mourtzis et al., 2016). In fact, this factor is being highlighted since the reduced competencies and know-how of the available suppliers in emerging economies is inducing challenges to the operation process in the supply chain (Soydan, 2012). In emerging markets, the upstream part of the supply chain is definitely determining the path of every business activity and while this instability persists, it will not be easy to thrive in this economy (Altmann and Engberg, 2016).

(4) **Non-skilled labour force:** Filling the skills gap in emerging economies is a challenge that developing countries are persistently aiming to achieve (Tiwari and Herstatt, 2012; OECD, 2010). However, today the labour constraints are still very evident in emerging economies since the education level is much lower than in developed economies. In fact, the jobs that require higher qualifications are not performed properly hence threatening the productivity of the task and the quality of the output (The Guardian, 2014). It should be reinforced that this shortage in human capital, although usually seen as a weakness, must be attentively observed since it also represents a huge opportunity for economic growth (European Union, 2016).

(5) **Water and energy constraints:** The frequent power outages and water shortages are continuously threatening the viability of all business activities operating in emerging economies (Bhatti, 2012; Levänen et al., 2015; Hossain, 2016). Unfortunately, many emerging countries are now facing the worse water situation of all times. The demographic expansion is achieving exorbitant numbers and this populational rise combined with the hurry of extracting water to fulfil the demand, led to a declining in ground water levels and to a catastrophic water management. Apart from the water, the regular power cuts also represent a constrain for every company that aims to move its manufacturing facilities to emerging economies (Tiwari and Herstatt, 2012). In fact, in order to achieve a certain level of stability, companies must have their own fuel generators to ensure a certain degree of production stability (Euromonitor International, 2014). However, this solution threatens the environmental sustainability of the business activity.

(6) **Availability of local materials:** Contrary to what happens with the water and energy, the local materials are almost never in shortage in emerging economies (Soni, 2013; Rosca et al., 2016; Hossain et al., 2016)). A great advantage of producing in emerging countries is that the distribution/procurement costs tend to be lower since the raw materials transportation is reduced (Rocca, 2016). When these local materials are successfully incorporated into the manufacturing process and in the final product, not only the company benefits from this local harmony but also the surrounding areas that boost their economic growth.

(7) **Innovation-based mindset:** As previously mentioned, in emerging markets, there is a significant lack of physical infrastructures and frequent failures in energy supply (Soni, 2013; Zeschky et al., 2014; Sarkar and Pansera; 2017). However these institutional voids were precisely what introduced an innovation mindset in companies and organizations that aim at developing products and services to emerging markets (Bhatti and Ventresca, 2013; Rosca et al., 2016). Thus, although the multiple constrains, in emerging markets, companies usually adopt a flexible and innovation mindset in order to guarantee consistency between their business models and the existing market conditions.

5.1.2. Market Conditions in Developed Markets

As in emerging markets, there are some characteristics that can express the situation lived in developed markets. Several characteristics could be selected to further analysis. However, there were selected six since they embody a representative sample that provide a comprehensive view of what is being perceived by companies operating in developed markets.

(1) **Government Regulation:** Nowadays, governments from developed economies are framing the market evolution with new regulations that boost sustainability to a new era (Rocca, 2016). Among the environmental initiatives, governments are requiring business to be more resource efficient, to reduce their carbon footprint and to promote inclusive growth (United Nations Development Programme, 2014; Radjou and Prabhu, 2015). In fact, organizations that manufacture its products in developed economies must follow and implement these legislations in order to guarantee a well- and legal-functioning of their business activities. A possible negative aspect about these regulations is that it can represent an inhibitor to innovation. The fear of failing in applying these rules can restrict the power that companies have to innovate and to find new and adaptable solutions.

(2) **High production costs:** Producing in developed countries is more expensive than producing in emerging countries. This production cost is related to manufacturing or creating goods and services that directly generated revenue for a firm. Breaking down the cost of production, it is possible to distinguish two types of costs: the direct and indirect costs. The direct costs comprise all the costs related to the materials and labour needed to manufacture the final product. In fact, these both variables, i.e., the materials and labour, are much more expensive in developed markets (Ellen MacArthur Foundation, 2017). Regarding the indirect costs, the infrastructure renting, the administrative salaries and utility expenses are much higher in developed markets (Investopedia, 20. Thus, since both costs are higher in emerging markets, the total cost of production is also bigger, which can easily compromise to the profitability of a company manufacturing in developed economies.

(3) **Material constrains:** Contrary to what happens in emerging economies, in developed markets, material constrains are threatening the viability of businesses (Geissdoerfer et al., 2016; Levänen et al., 2015). In fact, the majority of the materials used in the manufacturing process come from emerging economies where the environmental conditions, the increasingly agriculture exploitation and the underexplored territory is favouring the production of essential raw materials. This implies that companies in developed economies must import raw materials from emerging markets which leads to an increase in the procurement costs.

(4) **Proficient suppliers:** Maintaining a strong relationship among the supply chain stakeholders is crucial to guarantee that the final clients receive their products in time and in the best condition possible, overcoming whenever conceivable their expectations. Suppliers are responsible for delivering product on time and with high quality and their role affects directly the excellence of the final product (Ellen MacArthur Foundation, 2017). In developed countries, the relationship with suppliers is increasingly gaining more attention and the Supplier Relationship Management platform is progressively being used. The suppliers in developed economies are mostly qualified and they are performing their activities under ISO standards which facilitates the quality control of the manufacturing organizations (Rocca, 2016).

(5) **Funding and incentives:** Currently, many companies based in developed economies are receiving funding from several institutions and organizations that support the implementation of sustainable, inclusive and smart practices that promote the economic growth of the country or region (Bhatti, 2012; Radjou and Prabhu, 2015; Chamber of Commerce, 2015; Ellen MacArthur Foundation, 2017). Taking for instance the European Union as example, the Europe 2020 strategy was designed to improve the competitiveness and productivity of the European region as well as underpin a sustainable social market economy (European Union, 2016). They have provided a large amount to fulfil this requirement and the companies that want to receive this funding can submit their applications via online.

(6) **Technological breakthroughs:** Technological improvements represent a key driver for companies that envision to achieve a strong and competitive position within developed markets (Radjou and Prahbu, 2015; United Nations, 2015). The new digital era is transforming the all company transversal processes from forecasting & sales management to after-sales client support. The

inclusion of technological advances in the data collection and treatment are crucial to engage a continuous improvement policy within the company and also determinant to increase customer experience and facilitate customer interaction. Besides this commercial aspect, technology is definitely vital to increase coordination among departments and to increase efficiency within manufacturing processes (Rao, 2014). Currently, companies producing in developed markets are making strong efforts to achieve high technological levels and whenever possible, they desire to be always a step ahead of their competitors.

5.1.3. Consumers' Characteristics in Emerging Markets

In emerging markets, there are four main characteristics that can define a potential customer in terms of wishes, mindsets and buying patterns

(1) **Basic needs:** In emerging markets, there are billions of customers who still have basic needs (Prahalad and Mashelkar, 2010; Zeschky et al., 2011; Rocca, 2016). The healthcare and education services are far from developed and due to the lack of utility infrastructures, the access to energy, water and food is also very restricted (Soni, 2013). Thus, consumers in emerging markets desire products or services that can fulfil their basic needs such as a solar power that illuminate their houses or even a water filter that creates access to drinkable water.

(2) **Lack of product knowledge:** The educational level in emerging countries tend to be lower than the educational level in developed countries. This aspect reflects on the knowledge that consumers have about the product (Bhatti and Ventresca, 2013). Usually, in emerging markets, consumers are not totally aware of the product functionalities and they do not know what is the most sustainable and effective way of using them (Rosca et al., 2016). Companies that aim at fulfilling the requirements of emerging consumers much ensure that its marketing campaigns covers all the elements that can clarify and teach consumers. It avoids significant and unnecessary losses and both, companies and consumers, win from this action.

(3) **Focus on functionality:** Taking the previous point as a starting element, it can be said that since the consumers are not so well informed about the product benefits and usefulness, the product itself must be as self-explanatory as possible (Tiwari and Herstatt, 2012; Radjou and Prabhu, 2015). Emerging consumers desire functional products without extra features that do not add significant advantages to them (Simula et al., 2015). They ambition intuitive and ergonomic solutions more than complex and visual adornments (Petrick and Juntiwasarakij, 2011)

(4) **Risk adverse:** In emerging markets, consumers have lower incomes which reduces their availability and willingness to easily spend their money in products that do not fulfil their requirements and needs (Soni, 2013; Roland Berger Strategy Consultants, 2014). This risk adversity instilled in their mindset encompasses great difficulties to companies that aim to satisfy emerging consumer needs (Soydan, 2012). Among few alternatives, some companies endeavour to persuade consumers through mouth to mouth marketing, where product capabilities and insights were shown directly to the end-user. However, pricing is determinant to consumers in emerging markets and companies' pricing strategies must be aligned with the current availability of consumers in a sense that products

should be affordable enough to be competitive within a market recognized by low income levels (Bhatti and Ventresca, 2013; Rocca, 2016).

5.1.4. Consumers' Characteristics in Developed Markets

In developed markets, the consumer characteristics are quite different from the previous presented and there are four that can be stood out.

(1) **Conscious consumerism:** The enormous amount of options available in the developed market to satisfy the same customers' requirements led to a transformation mindset in consumers. This increased volume of existing alternatives has instilled near consumers a new way of buying products and services. Consumers desire to know and understand all the product specifications and differences among products to ensure that their procurement behaviour has followed a conscious and responsive path (Brem and Ivens, 2013). In order to overcome this competition, companies have to develop differentiation strategies by creating environmental-friendly products and by promoting responsible consumption marketing campaigns.

(2) **Complex needs:** Contrary to what happens in emerging markets, consumers in developed economies seek complex and fully personalized experiences in their interaction with products and services (Puri et. al., 2015; Rocca, 2016). Frequently, consumers desire more convenient options in which they can fulfil a list of needs by just acquiring one single service or product. Besides this all in one choices, consumers in developed markets also leverage the visual element of the product which position companies in a delicate situation where they have to aggregate all complex needs in a solution in order to achieve differentiation and success.

(3) **Sustainability awareness:** Consumers in developed economies are increasingly perceiving the impact of unsustainable activities and are desiring products and services with beneficial features concerning social and environmental impacts (Rosca et al., 2016; Pansera and Sarkar, 2016). Their changing buying patterns are increasingly emphasising the importance of a radical drift in the resource and time-consuming behaviours followed by several multinationals. There is clear pressure placed on companies to develop solutions that do not harm and pollute the environment and improve the well-being of the planet.

(4) **Price sensitiveness:** The economy in developed countries is plummeting and disposable incomes are significantly reducing (Hossain, 2016). This decrease has changed consumer behaviours in a sense that they are searching for affordable solutions that meet their increasingly tight budgets. Companies are under a trade-off situation where they have to find a solution to continue to satisfy the complex needs of consumers in developed countries while maintaining a competitive and affordable pricing strategy.

5.2. Market Characteristics Framework Conclusions

The characteristics of developed and emerging markets exposed in the market characterization framework were retrieved from the frugal innovation literature and validated by a focus group methodology. These characteristics include the markets condition characteristics that encompasses all the featured that are not linked to consumers (such as resource constrains or availability, political and economic insights, etc) and the consumers characteristics that reflect the consumers' wishes, mindset and buying patterns.

These characteristics were 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 threat to the success and viability of frugal innovation within the market.

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 mote significant in developed markets).

6. Framework for Environmental Practices in Frugal Innovation

This chapter presents the Framework for Environmental Practices in Frugal Innovation (FEPFI). Section 6.1. explains the scope of the FEPFI and the methodology to create frugal products with environmental practices. Then, in Section 6.2., the benefits that derive from the final framework are investigated regarding its implication for theory and practice. Finally, Section 6.3 summarizes the findings and arouses a conclusion on the limitations of the FEPFI.

6.1. Framework Scope and Use

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 10, 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.

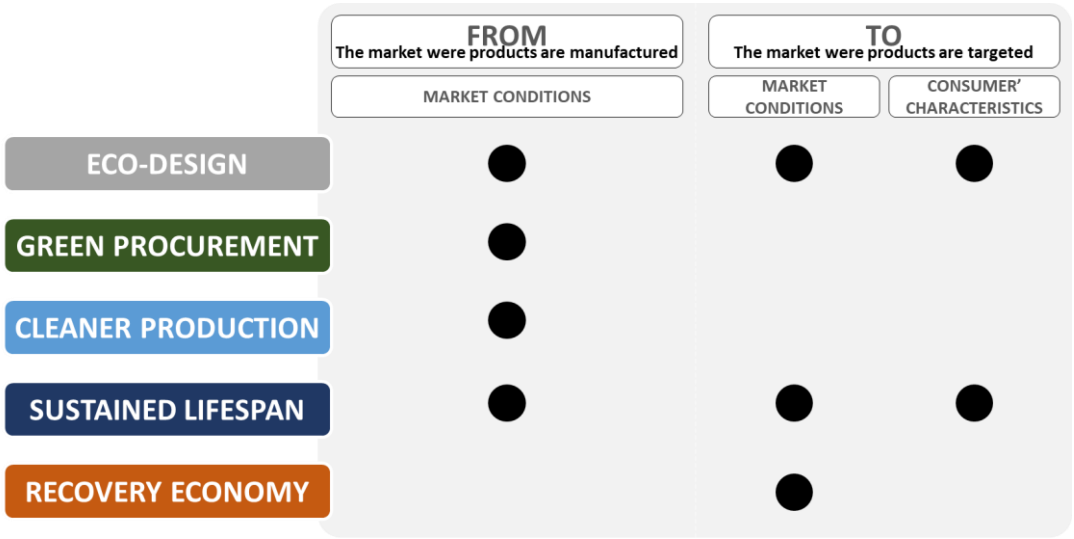


Figure 10: Indicative Table

The following bullets summarizes the content of the matrix:

(1) The practices allocated to the **eco-design** activity are deeply related to the conceptualization of a product and with the set of materials used in the product design. Thus, a company when developing frugal products and aiming at implementing eco-design practice must consider three main features: 1) the characteristics of their own market condition since the company's ability to implement this list

of practices depends on the characteristics where frugal products are being manufactured; 2) the characteristics of the market condition where the products are being targeted since governmental aspects and infrastructure deficit may impact the capability and the importance of implementing certain eco-design practices; 3) the characteristics of the consumers living in the markets where products are being targeted since the design of the products must be adequate to their requirements and wishes.

(2) The practices integrated in the **green procurement** are exclusivity related to an important group of value chain stakeholders: the suppliers. As reported in the chapter 2, in the frugal innovation state of the art, a key core characteristic of frugal innovation is the fact of being local and it includes having local suppliers closely working and cooperating with the frugal innovations producers. However, the ability of establishing strong business relationships with suppliers as well as the ability of implementing green procurement practices fully depends on the market condition where the products are being manufactured.

(3) The practices concerned to the **cleaner production** activity, have their degree of applicability dependent on the characteristics where frugal products are being manufactured. Thus, when a company aims at developing frugal products by implementing cleaner production practices must consider the characteristics from their own market to be well-succeeded.

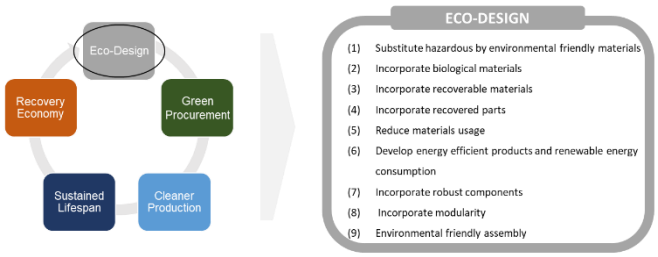
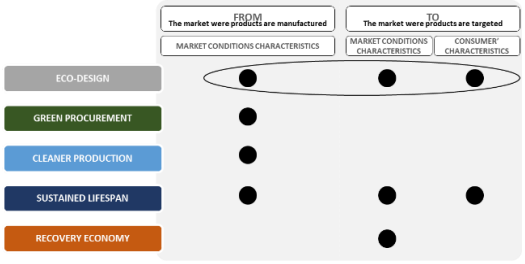
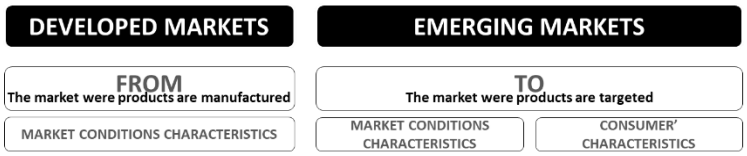
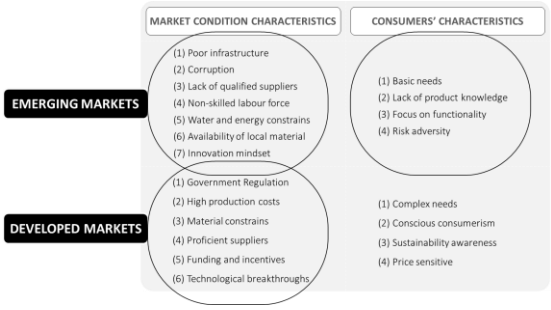
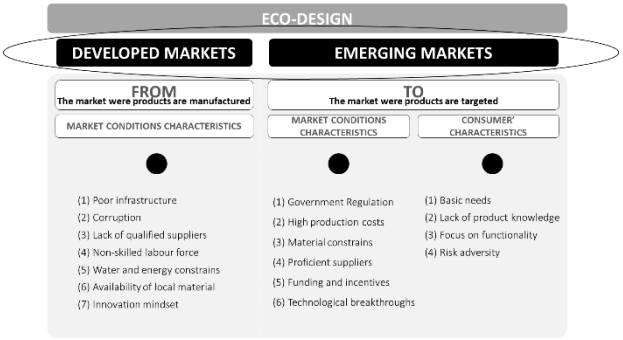
(4) The practices allocated to the **sustained lifespan** activity aggregate a wide scope of practices since they encompass the sales and use phase. Thus, a company when developing frugal products and aiming at implementing sustained lifespan practices must consider three main aspects: 1) the characteristics of their own market condition since the company's ability to implement this list of practices depends on the characteristics where frugal products are being manufactured; 2) the characteristics of the market condition where the products are being targeted since governmental aspects and infrastructure deficit may impact the capability and the importance of implementing certain eco-design practices; 3) the characteristics of the consumers living in the markets where products are being targeted since the design of the products must be adequate to their requirements and wishes.

(5) The practices integrated in the **green procurement** are exclusivity linked to the disposal activity at the end of the use phase. Thus, when a company is developing frugal products and aims at implementing recovery economy practices it must consider the characteristics of the market condition where the products are being targeted since governmental regulations, infrastructure deficit and other key characteristics may impact the capability to recover frugal products.

6.1.1. FEPFI Quick Reference Guide

In order to demonstrate the connection between the indicative table (see figure 10), the Environmental Practices Framework and the Market Characterization Framework, an illustrative presentation will be following conducted. Table 17 presents the FEPFI by displaying its methodological steps using a specific example as reference.

Table 17: 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.	
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).	
Step 3: Identify the market where product is being manufactured and the market where product is being targeted.	
Step 4: Select the quadrants presented on the Market Characterization Framework according to the black balls of the indicative matrix.	
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.	

6.2. FEPFI Implications for Theory and Practice

This subchapter presents the main advantages of the framework in an academic and practical purpose. Section 6.2.1. discourses on the framework implications for theory and refers the main contributions for the frugal innovation state-of-the-art. Section 6.2.2 presents the main outcomes of the framework in a practical context and highlights the main advantages of the framework for frugal innovators.

6.2.1. Implications for Theory: Academic Purpose

The majority of studies have recognized frugal innovations as environmental sustainable solutions (Basu et al., 2013; Bound and Thornton, 2012; Sharma and Iyer, 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.

Tata Nano car, considered a frugal innovation by 18 documents, was designed in collaboration with ultra-relevant upstream stakeholders: the suppliers (practice: cooperate with suppliers for eco-design). MAC 400 electrocardiogram, considered a frugal innovation by 16 documents, was design through a focus on core functionalities, portability and miniaturization (practice: reduce materials usage). Mitticool fridge, considered a frugal innovation by 10 documents, embody a simple technology that functions on the cooling effect of water evaporation with no need of electricity to operate (practice: develop energy efficient solutions and renewable energy consumption). Nokia 1100, considered a frugal innovation by 7 documents, includes multiple address books for several users since different people in a family share a handset (practice: encourage asset sharing).

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.

6.2.2. Implications for Practice: Managerial Insights

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:

(1) First, the practice 'reduce materials usage' places a clear focus on product functionality and implies a redesign strategy where the extra features that do not contribute to the main purpose of the product are removed. This practice minimizes the procurement and production costs since less virgin materials were required and fewer features were added to the product.
(2) Second, the practice 'incorporate robust components' slows down the rush to initiate the recovery of a product. In fact, by incorporating components that endure wear and harsh conditions, the extension of products lifespan and durability can be empowered. Therefore, the need to extract raw materials to produce new products could be reduced and economic savings could be directly reached.
(3) Third, the practice 'incorporate biological materials' increases the inclusion of biodegradable materials on products which can be returned to biosphere after its use. This means that by incorporating biological nutrients, the disposal and recovery costs are eliminated and some economic savings can be directly obtained.

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, presented on chapter 4.2., 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.

The previous information refers the main advantages of the FEPFI reading the Environmental Practices Framework. However, it is also relevant to analyse the practical benefits associated with the market characterization also presented in the FEPFI.

In fact, through FEPFI, frugal innovators have access to a schematized matrix that enumerates the main characteristics of emerging and developed markets in terms of market condition and consumers' characteristics.

(1) **Market conditions characteristics:** Nowadays, organizations must pursuit the need of fully understanding the surrounding environment in which they are inserted. In fact, they must constantly adapt their business model and activities to those changing atmosphere conditions in order to ensure that they establish a sustainable and competitive advantage position in the market. The market conditions on emerging markets and on developed markets are completely different and, studying and understanding these characteristics is a requirement to achieve a successful and consistent performance.
(2) **Consumers' characteristics:** Besides, a major prerequisite for a company to stay within the success boundaries, is to know, in as much detail as possible, their potential customers. In order to set a customer profile, the company must understand their consumption behaviours, tastes and routines. This allow the company to understand certain patterns and to recognise which product specifications are most appreciated and valued.

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 constrains and decide the actions that should be implemented according to their market context.

6.3. FEPFI Limitations and Conclusions

The FEPFI results from the integration of the Environmental Practices Framework and the Market Characterization Framework. This final framework 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. The framework is composed by four main methodological steps: 1) Select the environmental practices from the circular economy value chain activities that compose the Environmental Practices Framework; 2) Retrieve from the indicative matrix the type of characteristics that must be considered to implement the selected environmental practices (see the black balls); 3) Identify the market where product is being manufactured and the market where product is being targeted; 4) Select the quadrants presented on the Market Characterization Framework according to the black balls of the indicative matrix. After completing these 4 steps, the market characteristics that a frugal innovator should take into consideration to apply environmental practices from a certain circular economy activity are presented.

FEPFI aims to be instrument that helps frugal companies and entrepreneurs in improving companies' environmental performance of the entire frugal innovation value-chain. However, the framework is a generic tool that should be adapted to specific applications. This holistic perspective of the framework raises a framework limitation: the environmental practices proposed tend to be very generic.

The ability to implement the environmental practices proposed fully depends on the frugal solution that is being developed and also on the market characteristics. Regarding the frugal solutions, in the case study analysis, an analysis of the products by sector, by final purpose or by market was not performed. Thus, the applicability of the proposed practices to specific group of products was not assessed. Regarding, the market characteristics they were divided in emerging and developed markets. However, some presented characteristics are country-dependent which means that market conditions and consumers characteristics in an emerging country can have different characteristics than market conditions and consumers in another emerging country. Since the characteristics are also generic and considered in two maturity stages, the applicability of the proposed practices in a specific country was not evaluated.

The second limitation is related with the scope considered in the establishment of the circular economy activities. In fact, the five activities belong to the same coverage level, i.e., they are consistent in terms of specificity. However, the practices that were considered inside of each activity have different degrees of specificity. The activity eco-design has practices that are more specific while the remaining activities have more generic practices. This happens because frugal innovation is a product-based innovation focused on serving a specific need and on incorporating functionality.

The distribution activity was not considered in the framework since conclusions about the best practices are quite difficult to assess when there is a lack of information regarding the distance between the company that offers frugal product and the consumers that are targeted. Frugal innovators should evaluate practices and assess which fits with their specific context.

The last limitation is related with the acceptance of the framework by the stakeholder involved in implementing the practices considered in the framework., mainly the top management. The efficiency and effectiveness of these practices depends on the institutional positioning and on the capacity and providence of decision makers to develop and implement proactive, integrated policies and strategies that stimulate the inclusion of this environmental sustainable practices.

7. Conclusions and Future Work

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.

In order to understand the feasibility of this idea, the insights of both approaches were studied. First, the frugal innovation theoretical and practical thoughts were analysed in order to understand the evolution of frugal innovation definition, the core characteristics of the frugal products and the market potential in developed and emerging countries. In this first stage, it was also performed a literature review on frugal innovation whose results shown that, whilst most documents recognized frugal innovations as environmental sustainable solutions, none have deeply addressed the environmental pillar with the deserved attention. Second, the theoretical and practical understandings of circular economy were investigated in order to comprehend the fundamentals of its three main principles as well as the activities that are crucial in a circular economy strategy. These activities were classified into a new taxonomy that resulted in six broad activities: 1) eco-design; 2) green procurement; 3) cleaner production; 4) sustained lifespan and 5) recovery economy.

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.

Regarding the FEPFI implications for theory and practice, there are two major contribution that stood out. First, the majority of scientific and theoretical studies have recognized frugal innovations as environmental sustainable solutions (Basu et al., 2013; Bound and Thornton, 2012; Sharma and Iyer, 2012; Rocca, 2016) but none document has deeply addressed the environmental pillar with the deserved attention. Thus, through the framework, the connection between frugal innovation and environmental sustainability was demonstrated: the proposed environmental practices are already being implemented in frugal innovation supply chains. Using the main outcomes of the developed framework 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. Second, the FEPFI is 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.

Three main areas for future research are suggested. First, focusing on a specific circular economy activity could contribute to the extension of the proposed environmental practices presented on the framework. The knowledge and the number of practices allocated to a specific activity would increase and a direct comparation between practices should be performed to better understand their economic viability and environmental impact. The eco-design should be the first activity to be analysed in greater detail since: 1) its represent the first step of the circular economy cycle 2) frugal innovation is a product-based innovation in which product functionality, performance and simplicity entail a huge relevance.

Second, it would be advantageous to develop a product from beginning following the proposed environmental practices. It would enable the measurement of the impact of each practice and the numeric evidence could contribute to assess the practices that better fit with the frugal innovation specific characteristics.

Third, a market analysis to assess the degree of applicability and degree of impact of each environmental practice within a specific market should be developed. In fact, the market where the frugal product is being developed and the market that is being targeted strongly influences the ability of implementing or not implementing certain practices. For instance, the practice 'Select suppliers by environmental criteria' can be an easy measure to implement in a developed market based company but an unrealistic practice to adopt in an emerging market based company since having at least one supplier who meets the minimum quality requirements imposed by the company is more than satisfactory.

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Annexes

Annex A: Frugal Innovation Case Studies

Case	#	Case	#	Case	#
Tata Nano	18	Haier's washing machine	3	Zhongxing X-Ray Machine	2
GE ECG (MAC 400)	16	Rickshaw Bank in India	3	Awaaz.De - Voice Message Board for Education	2
GE Ultrasound (LOGIQ Book)	14	Micromax's mobile phone	3	Kerala Palliative Care 4 Motorcycle-based tractor	2
Aravind Eye Care	12	Unilever's washing-powder sachets	3	ToughStuff	2
ChotuKool	12	Dachangjiang Motorcycle	3	Dacia Logan	2
Tata Swach	12	Nokia 1200	3	Bone Drill - Lunar Design	2
Mitticool	10	Nokia basic phones	3	careHPV	2
M-Pesa	9	A Little World	3	Harman's home infotainment systems	2
Jaipur Foot	9	Naandi	3	Mindray- healthcare products	2
Tata Ace	9	Kopo Kopo	3	Patient Monitoring System	2
Vortex ATMs	8	300$ House	3	Cookit - Solar Cooker International	2
Narayana Hospital	8	Bamboo Microscope	3	Liter of Light	2
Husk Power Systems	7	WE CARE Solar Suitcase	3	Kenya Ceramic Jiko (KCJ) Stove	2
Nokia 1100	7	Well Baby Bassinet	3	Ultrasound device GE Vscan	2
Aakash Tablet	7	Fetal Heart Rate Monitor	3	One Laptop per Child	2
Embrace	6	Generic Drugs	3	Avaz Speech Synthesizer	2
SELCO	6	HMI Line panel	3	IKEA furniture	2
Bharti Airtel	6	Multix Select DR machine	3	Siemens SMART line	2
Logitech mouse M125	5	Foldscope	3	KickStart's affordable and efficient pumps	2
EKO mobile phone banking	5	Electronic Voting Machine (EVM)	2	Philips's bedside patient monitoring system	2
Mettler Toledo	5	mOm	2	Conceptos Plasticos Recycled plastic houses	2
Easy Paisa	4	Nokia's 101	2	Coolar Solar energy fridge	2
Bamboo Bike	4	Unilever's Pureit	2	Columbia-Asia Healthcare	2
Oorja Stove	4	Vodafone Rs.10 pre-paid cellular phone balance	2	Wockhardt hospital - Bone Hearr Surgery	2
Siemens' Computed Tomography Scanner	4	Firefly - treat neonatal jaundice	2	Robotic Hand - Sandia National Laboratories	2
GE Lullaby baby warmer	3	BYD-Lithiumion Battery	2	Sarvajal Water ATMs	2
Mahindra & Mahindra's small tractors	3	Galanz's microwave	2	Toyola Energy Ltd "coalpot" stoves	2
Grameen Bank's microfinance	3	Haier's fridge	2		

Case	#	Case	#	Case	#
Immunoassay-based fabric chips	1	Invention Labs	1	Energy made in Uganda	1
Shakerscope	1	Kutcha house	1	Barefoot college	1
eRanger - ambulance for rural	1	Low cost sanitary toilets	1	Open- source wind turbine	1
Unilever's 1 rupee shampoo	1	Bubble continuous positive airway pressure device (CPAP)	1	Upesi stove	1
Mobile e-learning in Bangladesh	1	Micro-PCR device	1	Thermoelectric cook stove “Nicaragua energy”	1
Haier’s air conditioners	1	Missile	1	Annapurna Iodised Salt	1
10 Lenovo $300 laptop	1	Oral misoprostol	1	Chamak Laundry Service	1
Siemens’ wastewater treatment	1	Oral rehydration therapy	1	Danimal Yoghurt	1
“missed call” service in India	1	OSDD	1	Dial 1298	1
Acme power interface unit	1	Ponseti method - gold standard treatment of club foot	1	E-Health-Points	1
ATM on wheels	1	Probe for Detecting Tuberculosis	1	Protos	1
Scooter-powered flour-mill	1	Radio Telescope	1	Reuters Market Light	1
Superseva	1	Reverse engineered vaccines	1	Solae	1
Medicall in Brazil	1	Small sachets of Tide for one rupee	1	Vaatsalya Health	1
bCPAP for new born breathing	1	Smart medicine pack by Microsoft Research India	1	Village Phone	1
Bahria Town	1	Super Religare Laboratories’ Blood collection	1	Water Health	1
Solvatten	1	Vivian Fonseca- SMS message to control diabetes	1	Cisco and NetHope: Emergency NetReliefKit	1
HTC $30 mobile	1	WiMax	1	Solar Sister: Avon Style Solar Product Distribution	1
Beating Heart Surgery	1	XCyto Screen series	1	Square Kilometer Array	1
$5K Awami Villas	1	Craftskills East Africa limited	1	Spike missiles	1
Lifestraw	1	Mexico’s Cemex: Patrimonio Hoy	1	Accor Ibis Budget hotel chain	1
CheX	1	GVK- EMRI	1	Briago braille printer	1
D-Rev	1	Lupin Pharmaceutical	1	BrickPi Bookreader	1
Dry-Tri	1	Maruti 800	1	Local Motors rally fighter sportscar	1
Fixed-dose combinations of Anti-retroviral drugs for AIDs	1	Maruti Alto	1	Fairwaves GSM base station	1
Food fortification with Iodine and Iron	1	Toyota Qualis	1	Grameen Shakti (GS) Biogas	1
Hole in the wall	1	Hero Honda Spender	1	Frugal Innovation for Empowerment	1
HospIS project	1	Boond LTD	1		

Case	#	Case	#	Case	#
Frugal Cotton Deshelling Mansukhbhai	1	Water Filter - Ion Ag+	1	Tetra Pak's design	1
Agricultural Biomass Gasifier A	1	G-Thrive	1	Cummins Engine Company - low horsepower diesel engine	1
MotionECO	1	Solar Systems - Illu Mexico	1	ZPMC Harbor Cranes	1
Eco-Fuel Africa (EFA) - Carbon neutral fuel	1	HabiTec	1	Wine refrigerator	1
ProPlanet - Recycled tapperware	1	Lotus Food	1	Focus Twisting Machines - Volkmann	1
ModRoof - Rematerials	1	Sun King Mobile Light	1	Three-wheel Ambualnce	1
Clean Cookstoves - Technology and fuels	1	Solar System - Onergy	1	Darshana projector	1
Exo - Reaction	1	Pollinate Energy - Solar System	1	Laptop distribution	1
Mozambikes	1	Irrigation system - Global Easy Water Products	1	Guangzhou car rental	1
Glatt Stove - La Estufita	1	Solar products - Empower Generation Solar products	1	DTH Tata Sky	1
Optic Group ICH - Recycled PET glasses	1	Solar products - Thrive	1	Bamboo Windmill	1
BanaPads - Banana pad for women	1	Echale a tu casa	1	Dabbawalla bags	1
M-Kopa solar IV Solar Home System	1	Jibuco Drinking water access	1	Ginger Hotels	1
ReMotion Knee	1	mPedigree Health application	1	Hepatitis Vaccine	1
Child Vision - CVDW	1	M-Farm Agriculture application	1	Soaps	1
Grit Freedom Chair - GRIT	1				