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CIRCULAR ECONOMY: WHAT IS THE LEVEL OF KNOWLEDGE IN THE PORTUGUESE ORNAMENT STONE INDUSTRY SECTOR?

Milena Kaupp

Master's in Management of Services and Technology

Supervisor:
Isabel Cristina Duarte de Almeida, Assistant Professor at Department of Marketing, Operations and General Management
ISCTE Business School-IUL

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RESUMO

A escassez de recursos e o consumo crescente estão a forçar as empresas e os governos a repensar o actual quadro linear dominante, em que os produtos são descartados após a sua vida útil. A Economia Circular propõe um modelo empresarial mais sustentável e eficiente em termos de recursos. Como se espera que a construção esteja sujeita a um crescimento constante nos próximos anos, a indústria da pedra como fornecedora de matérias-primas desempenhará um papel crucial na transição para uma Economia Circular. Serão necessários novos modelos de negócio, tecnologias e métodos para desenvolver um modelo de funcionamento sustentável na indústria. Embora a adaptação de um modelo de negócio circular ofereça benefícios económicos, muitas empresas enfrentam desafios na transição. O objectivo desta tese de mestrado foi investigar os motores e as barreiras na adaptação de um modelo de negócio circular para pequenas e médias empresas na indústria portuguesa da pedra, tendo sido realizadas entrevistas, numa abordagem qualitativa, com representantes de empresas que operam no mercado português. Com esta investigação pretendeu-se sustentar a criação de um estudo de caso pedagógico, num contexto que é pertinente para o desenvolvimento económico sustentável. Pretende-se que este caso venha a ser aplicado e trabalhado com Mestrandos da área de Gestão.

Palavras-chave: Sustentabilidade, Cadeia de Valor, Indústria das Pedras, Objectivos de Desenvolvimento Sustentável, Benchmarking.

Códigos de Classificação JEL: Q01 (Desenvolvimento Sustentável); M11 (Gestão da Produção); O13 (Agricultura - Recursos Naturais - Energia - Ambiente - Outros Produtos Primários).

ABSTRACT

Resource scarcity and growing consumption are forcing businesses and governments to rethink today's dominant linear framework, in which products are discarded after their useful life. The circular economy proposes a more sustainable and resource-efficient business model. As construction is expected to be subject to constant growth in the upcoming years, the ornament stone industry as a provider of raw materials will play a crucial role in the transition towards a circular economy. New business models, technologies and methods will be necessary to develop a sustainable operating model in the industry. Even though the adaption of a circular business model offers economic benefits, many businesses face challenges in the transition. The aim of this master's thesis was to investigate the drivers and barriers in adapting a circular business model for small and medium-sized companies in the Portuguese ornament stone industry. Interviews were carried out, in a qualitative approach, with representatives of companies operating in the Portuguese market. With this investigation, we intended to support the creation of a pedagogical case study in a context that is pertinent to sustainable economic development. It is intended that this case will be applied and worked with Masters in the Management area.

Keywords: Sustainability, Value Chain, ornament stone industry, Sustainable Development Goals, Benchmarking.

JEL Classification Codes: Q01 (Sustainable Development); M11(Production Management); O13(Agriculture • Natural Resources • Energy • Environment • Other Primary Products).

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LIST OF ABBREVIATIONS

ASSIMAGRA – Associação Portuguesa dos Industriais de Mármores, Granitos e Ramos Afins

BCSD – Business Council for Sustainable Development

BIM – Building Information Modelling

CE – Circular Economy

EIP – European Innovation Partnership

ERT – Electrical Resistivity Tomography

EU – European Union

GPR – Ground Penetrating Radar

IST – Instituto Superior Técnico

R&D – Research & Development

RMI – Raw Material Initiative

SME – Small and Medium-sized Enterprises

UN – United Nations

1 Introduction

1.1 Background of the study

Today's leading economic concept follows a linear model of production and consumption, in which raw materials are extracted and manufactured to products, that – after their useful life- are discarded as waste. Although the linear model is highly responsible for our economic growth throughout the last decades, it is now time to rethink the existing framework. The world's middle class is expected to double in size by 2030 to almost five billion people. Therefore, consumption will increase, driving up material intensity, input costs and price volatility. Furthermore, the pressure on scarce resources will not only affect the environment, but also the economy. Business leaders and policy makers are starting to rethink the current material and energy use and are searching for alternative business models (European Commission, 2018; Ellen McArthur Foundation, 2013).

The circular economy (CE) could provide such an alternative. Based on a restorative and regenerative design, it aims to reduce waste by prolonging the useful lives of materials and products while keeping their value. Circular business models, however, not only offer opportunities to reuse or remanufacture goods, but focus on a shift of the existing consumption model towards service systems (Ellen McArthur Foundation, 2013).

With an expected growth of the construction sector of 70% until 2025, it is essential to assess the opportunities for circular business models in the stone industry (HM Government, 2013). Several initiatives such as the Raw Material Initiative (RMI) of the European Union aim to provide solutions for a more sustainable approach of resource sourcing and manufacturing to secure resource supply and ensure the stability of European economy with a minimum of 30 million jobs related to the raw material industry (European Commission, 2020b).

The stone industry is composed by two main sectors: the industrial stone and the ornament stone sector. The focus of this work is the ornament stone sector.

1.2 Research problematics

The industrial development and increased consumption have led to an intense debate about the scarcity of resources and production of waste, which becomes progressively a threat not only to the viability of organizations themselves but also to the planet. As a result, in contrast to the linear model, a new business model emerges – the circular economy (CE) – which allows to dissociate economic growth from waste generation and is aimed at environmental protection, prevention of pollution and sustainable development. In CE, every constituent of a specific value chain needs to understand that the chain will lose once an indispensable resource is gone. Like each one of its constituents, the supply chain needs to operate within economic, environmental and social thresholds. Supply chain managers must develop

metrics that take the sustainability context into account, as well as building relationships with players across the entire chain. The concept only works if supply chain partners build up mutual trust in the sustainability information each partner is giving. Therefore, CE requires transparency about associated materials and financial flows of the product and its components during their entire life cycles (De Wit et al., 2018; Ellen McArthur Foundation, 2015).

99,9% of Portugal's businesses are small and medium-sized enterprises with a majority based, like most of the world economy, operating on the traditional economic model (European Commission, 2019a). Being one of the largest global exporters in the ornament stone industry, it would be interesting to ascertain the degree of knowledge of Portuguese small and medium sized enterprises (SMEs) in the ornament stone industry about the new business model, as well as their interest, opinion and potential adhesion to CE (Chambel, 2016).

Academic research has so far focused on the possible circular business models for big companies. However, due to their size, infrastructure and financial and human resources, SMEs in the ornament stone industry are in particular facing problems in the transition towards CE. Since in European countries, SMEs are representing the majority of businesses, they play a key role for the success of the European circular economy. Therefore, it is essential to understand what the current level of knowledge on circular business models is in SMEs, what their opinion on this topic is and whether or not they are able and willing to undergo the shift from a linear to a circular model.

1.3 Research objectives

The thesis presented will analyse the current state of research on the circular business models as well as possible enablers and barriers for organizations to adapt them. A literature review will give insight into the existing models and their implication until today. Different business models should be assessed in terms of their characteristics, pattern and approach to circularity. Furthermore, the literature research will help to understand the barriers that businesses, in particular SMEs are facing and which factors could promote the transition towards a circular model.

Since the circular economy is a topic, that is still in the transition from theory to practice, the thesis will be in the form of a dissertation. This will give the opportunity to deeply analyse existing scientific literature on the model as well as actual political regulations and projects. In order to assess the level of knowledge of CE in SMEs in the Portuguese ornament stone industry, interviews with experts will be conducted.

This thesis aims to

(1) assess the organization's knowledge on the circular business model, and

(2) know their interest, opinions and potential adoption.

1.4 Research questions

In this thesis, the central research questions should be assessed:

RQ1 What is the level of knowledge of the circular economy in Portuguese ornament stone industry sector?

RQ2 What are the key challenges and enablers for SMEs in the ornament stone industry in the transition towards CE?

1.5 Research methodology

The Literature Review will give a first insight into the current state of development of CE models and their implementation. First, the concept of the circular economy and the difference to the linear economy should be explained. Then, existing circular business models will be analysed and the application of the concept in the ornament stone industry will be assessed. Furthermore, it should be assessed what kind of challenges SMEs in the ornament stone industry are facing in the transition to a circular model and what could be possible enablers to support the shift. The focus will be the European ornament stone industry, in particular Portugal.

In the next step, Portuguese organizations operating in the ornament stone industry will be interviewed to gather primary data for the investigation of the research question. The interviews will give a better understanding – apart from theoretical literature – what the current state of knowledge, opinion and potential implementation approaches is.

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2 Literature Review

2.1 Limits of linear models and development of sustainable growth

The last decades of industrial evolution were dominated by a linear model of consumption and production, following a take-make-dispose pattern. In a linear economy model, materials are extracted, manufactured to products and later discarded by consumers when they are no longer of use. Population growth and global mass industrialization are overstraining the naturally regenerative system of the earth, resulting in an ecological overshoot (Lehmacher, 2016). The biosphere can already no longer supply enough resources to meet the human demand and the global population continues to grow. By 2030 the global middle-class is expected to increase to nearly five billion. As a result, consumption will rise accordingly, increasing resource scarcity and adverse effects on the environment. The linear model could also expose companies to risks since resource scarcity will drive up input costs and price volatility. In addition, the sharp rise in demand may further increase the risk of supply disruptions (Ellen McArthur Foundation, 2013).

As a consequence, alternatives for sustainable growth have to be developed and adopted. Approaches towards a more sustainable economy have been discussed for years and the meaning for sustainability in business has changed over the decades. While sustainability was first a matter of complying with legal constraints, it gained importance as a strategic approach during the late 1980s and early 1990s. With the turn of the century, sustainability became an aspect of management practices, which is triggering new business models.

The World Commission on Environment and Development already presented a widely recognized definition of the term sustainable development in 1987. In the so-called Brundtland Report sustainable development is defined as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). It furthermore defines sustainable development as a process of change, which requires a shift in investments, technological development and institutions to transform both, the economy and the society, in order to reach a more sustainable growth. In the following years, the responsibility of corporations to operate sustainable was more precisely defined and widely discussed under the term corporate sustainability. Elkington (1997) stressed that corporations should not only focus on their economic performance, but also on their environmental and social impact. While corporate environmentalism was first only seen as a matter of complying with legal regulations, it became a strategic aspect in the early 1990s. The Porter-Hypothesis identifies corporate environmentalism as an opportunity to create competitive advantage. According to Porter and Linde (1995), corporate environmentalism does not have to be a fixed trade-off between ecology and economy, but could instead trigger innovations, decrease production costs and improve the value for customers. Pollution could be reduced by eliminating economic waste resulting from inefficient and ineffective use of resources. Therefore, resource productivity could be a key factor for competitive advantage.

The Natural-Resource-Based View developed by Hart (1995) follows a similar logic. As stated by the author, pollution prevention, product stewardship and sustainable development are representing key strategies to achieve competitive advantage. These strategies may lead to costs savings, an increase in productivity and efficiency, competitive pre-emption by creating barriers through regulations and standards and could secure a firm's future place in the market.

In 1992 the Agenda 21 was published by the United Nations as a result of the Rio de Janeiro Earth Summit. The Agenda represents a non-binding action plan, providing guidelines for sustainable development and includes social, ecological and economical goals (Conference on Environment and Development, 1992). In 2015 additional sustainable development goals were included in the Agenda 2030. Such as goals for sustainable economic growth, innovations and responsible production and consumptions. These goals aim to improve global resource efficiency in production and consumption, thus enabling economic growth without harming the environment. In addition, industries and infrastructures should be transformed to be able to adopt environmentally sound technologies and to improve resource efficiency. Natural resources should be used efficient and waste should be eliminated through prevention, reduction, recycling and reuse. However, the Agenda also comprises goals that broaden the scope of corporate sustainability by including social concerns like the elimination of inequality and poverty. (UN General Assembly, 2015).

The extension of the definition of sustainability represents the recent trend of corporate sustainability, which integrates sustainability within management practices and includes social, environmental and economic concerns. In order to increase sustainability in corporations, structural changes, innovations and new business models are needed that provide alternatives for the traditional linear economy. Different schools of thought proposed alternative models.

2.2 Schools of thought

Different schools of thoughts have developed concepts that attempt to offer an alternative to the linear model. The concepts aim to create a more sustainable economy by closing the system and return resources instead of disposing them at the end of their lifetime. In the following, some of these schools of thought will be explained in detail.

A concept that seeks to exploit both, economic as well as ecological benefits, is the concept of Natural Capitalism. Natural Capital defines the world's stock of natural assets, including soil, geology, air water and living organisms. By building on resource efficiency and a shift in strategy, companies could operate sustainable while at the same time being profitable and competitive. Four main principles characterize the concept: dramatically increase the productivity of natural resources, shift to biologically inspired production models, move to a solution-based business model and reinvest in natural capital. The concept is based on a closed-loop system, in which output is either returned to the ecosystem or

recovered for further use, thus significantly reducing waste (Ellen McArthur Foundation, 2019; Lovins et al., 2005).

A similar approach is followed by the concept of Industrial Ecology. Taking ecological models as an example, the concept operates in a closed-loop system, where waste is reused as input. The industrial system has to consider its environment and connections, thus applying a system view (Graedel, 1996).

Likewise inspired by patterns of the nature is the concept of Biomimicry. Nature should serve as a model for sustainable design solutions for companies in terms of resource efficiency or waste reduction. Biomimicry could also trigger innovations. Key principles of the concepts are an efficient use of energy, recover resources, focus on diversity and encourage cooperation (Hargroves & Smith, 2006).

Regenerative Design, fundamentally influenced by John T. Lyle, describes a framework in which processes should regenerate their own consumed resources, such as energy or material. The concept focuses on system thinking, thus involving the society as well as the eco-system and factors in the impact of human actions on the environment. Instead of following a linear pattern, the model proposes a cyclical flow (Cole, 2012; Mang & Reed, 2012).

An approach that aims to replace the cradle-to-grave paradigm, characterized by a linear take-make-waste system, is the cradle-to-cradle concept. It was created by Braungart, a German chemist and McDonough, an American architect and still plays a major role in the development of sustainable systems (Ellen McArthur Foundation, 2013). The concept is based on three principles: everything is nutrition, use of solar energy and promotion of diversity. Product and industrial processes should be designed to transform materials into nutrients, that can flow in a biological or technical metabolism. The framework differentiates between products of consumption and products of service. The former refers to biological nutrients that can be consumed during their lifetime and later be returned to the natural environment. The latter describes technical nutrients that should be manufactured, recovered or reused in a closed-loop system. In this case, the consumer acts as a user, while the ownership remains with the manufacturer (Braungart et al., 2006).

Following the same line of thoughts, Walter Stahel developed a framework called Performance economy, that proposes a closed-loop system. But instead of focusing on “doing things right”, the concept aims to “doing the right things”. Besides creating resource efficiency, Stahel also states the potential of job creation and increased competitiveness. In order to prevent waste, product lifecycles should be extended and materials should be recycled or remanufactured. Conforming with the cradle-to-cradle framework, the concept proposes a shift from ownership to stewardship, meaning that businesses should sell performance instead of products (circular.academy, 2019).

A concept that combines many aspects of these schools of thought is the circular economy.

2.3 The circular economy

2.3.1 The concept of circular economy

The circular economy (CE) proposes a resource-efficient alternative to the linear end-to-end model. The Ellen MacArthur Foundation (2013) defines the circular economy as "an industrial system that is restorative or regenerative by intention and design" (Ellen McArthur Foundation, 2013:7). Instead of disposal at the end of a product lifecycle, the circular concept aims for restoration, the use of renewable energy, the elimination of waste and the design of new concepts and business models (Ellen McArthur Foundation, 2013). Based on the model of cyclical ecosystems, that are characterized by feedback-rich systems and waste-free mechanisms the concept has the purpose to create a zero waste, zero emission supply and value chain (Lehmacher, 2016).

Literature focuses on three different levels of CE: micro, meso and macro. The micro level concentrates on the company's effort to improve their processes towards sustainability and their willingness to implement CE. At this level, the company is aware of the positive impact of CE in terms of brand reputation and reduction in costs. At the meso level, companies form an industrial symbiosis, resulting in benefits for both, the economy and the environment. The macro level focuses on eco-cities and -municipalities that are built enabled by environmental policies and regulations (Prieto-Sandoval et al., 2017).

While the concept of CE has been influenced by many schools of thought, the introduction of the concept is commonly attributed to Pearce and Turner in 1989, who concluded that the linear system cannot be sustainable and explained the feasibility of economic flows in closed industrial loops (Andersen, 2007). Their theory was influenced by previous research of the economist Boulding (1966) emphasising that the earth is a cyclical system in which resources are limited and therefore consumption should be minimized.

In recent years, the concept has been widely discussed and the term has been defined in various ways. However, similarities in definition of the term can be identified.

Generally, the circular economy is defined as a circular system with closed-loop material flows. Instead of disposing the product after its useful life, as it is done in the linear economy, the closed-loop system recovers the good by returning or enriching products and materials (see figure 2.1) (Prieto-Sandoval et al., 2017). As a result, the circular economy creates a further value by extending the lifetime of products and materials. Furthermore, the concept aims to reduce waste by adopting the 3R principle: reduce, reuse, recycle. Reducing refers to the reduction of resource extraction and the decrease of resources in production and consumption (Ying & Li-jun, 2012). Reusing extents the lifecycle of a product for example through redistribution on the second-hand market. Recycling describes the process of recovering a product or materials weather to use them for their initial or for a new purpose (Ellen McArthur Foundation, 2013).

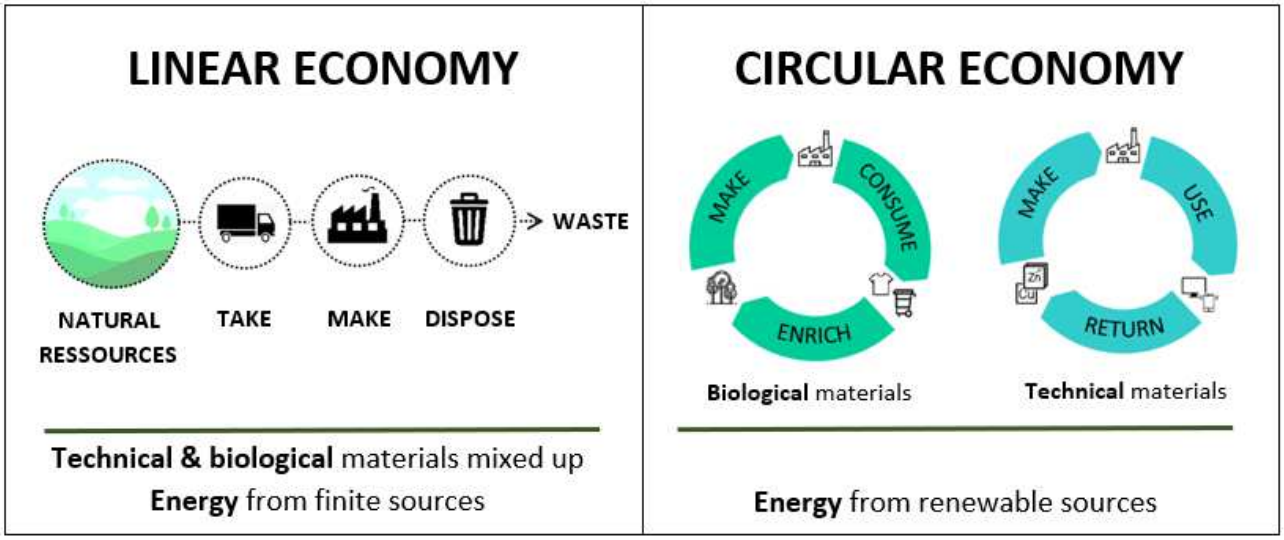

Figure 2.1 - The linear vs the circular economy (see datadriveninvestor, 2018)

According to the Ellen McArthur Foundation (2015) the circular economy is based on three principles: preserve and enhance natural capital, optimise resource yields and foster system effectiveness. The first principle, the protection of natural capital, should be achieved by controlling finite stock and by balancing renewable resource flows. Virtual delivery of demand should be considered and if necessary, renewable energy sources should be used. Material flows should include the whole system and should ideally be regenerative. The second principle aims to optimise resource yields through circulation. Products, components and materials should be designed to operate in technical and biological cycles. Remanufacturing, refurbishment and recycling of technical, as well as decomposition of biological components should be implemented into the system. The last principle, foster system effectiveness, attempts to prevent negative externalities through the reduction of damage to systems, for example food or education, and through managing external effects of pollution or land use.

These principles can be realized by adapting six characteristics:

1. *Design out waste:* Biological and technical components should be designed to avoid waste by intentionally aiming for disassembly or refurbishment or by making them fit within a material cycle. Biological components should be non-toxic, thus being able to be composted. Technical components should be reusable by maintaining a high quality with minimal use of energy.

2. *Build resilience through diversity:* Systems should aim for modularity, versatility and adaptivity to be resilient to a fast-changing environment. Instead of only building on efficiency in a uniform industry, circular systems should build resilience through a balance of efficiency and adaptability.

3. *Shift to renewable energy sources:* Energy sources used should be renewable by nature, thus reducing the dependency on resources and furthermore increasing the resilience of the system. Moreover, threshold energy levels should be reduced.

4. *Think in systems:* Businesses, people or plants influence each other in a system. Understanding the relationship between the different elements and their links and potential consequences should be considered in order to transit to a circular economy. Additionally, understanding the flows in a circular system provides information about the trade-off between efficiency and resilience.

5. *Think in cascades:* Biological materials should be cascaded through applications in order to create value. In the process, all components of a biological product should be considered for a diversified reuse.

6. *Feedback mechanism should reflect real costs:* Prices and other feedback mechanisms should be transparent and reflect full costs to be effective and enable the transition to a circular economy (Ellen McArthur Foundation, 2013a; Ellen McArthur Foundation, 2015).

De Wit et al. (2018) included additional key elements to the circular economy. Besides the use of renewable energy sources and a product design for the future, which is according to the definition of the Ellen McArthur Foundation, the authors added further characteristics:

1. *Preserve and extend existing products:* Lifecycles should be extended through maintaining, repairing and upgrading resources and take-back strategies should be adopted.

2. *Use waste as a resource:* Instead of disposure, waste could be used as a secondary resource and could be prevented through reuse and recycling.

3. *Rethink business models:* New business models should align to circular principles, exploiting the opportunities for value creation.

4. *Incorporate Technology:* Digital technology could enable the efficient use of resources and intensify the collaboration throughout the supply chain.

5. *Collaborate to Create Joint Value:* Supply Chain partners should collaborate closely to increase transparency in every step and to create shared value.

The circular model can be differentiated into biological circles and technical circles (see figure 2.1). The differentiation is necessary to design waste prevention and material recovery strategies based on the characteristics of the cycles. The technical cycle refers to stocks of finite materials, while the biological cycle includes renewable, biological nutrients. Consumption can only take place in biological cycles and describes the irreversible alternation of materials, such as food or cotton.

After their useful life, biological materials can no longer be used in their initial form. By returning them to the system through composting or anaerobic digestion new value can be created. In the technical

cycle, materials have to be recovered through reuse, repair, recycle or remanufacture strategies after a cycle has ended (Ellen McArthur Foundation, 2013).

Stahel (2010) also distinguished between two loops in the circular economy. In loop one goods or components are reused, repaired or reconditioned. In loop two, on the other hand, materials and molecules are recycled. While in loop one, the lifetime of products should be prolonged, loop two aims to turning goods into as-new resources after their initial lifetime through recycling.

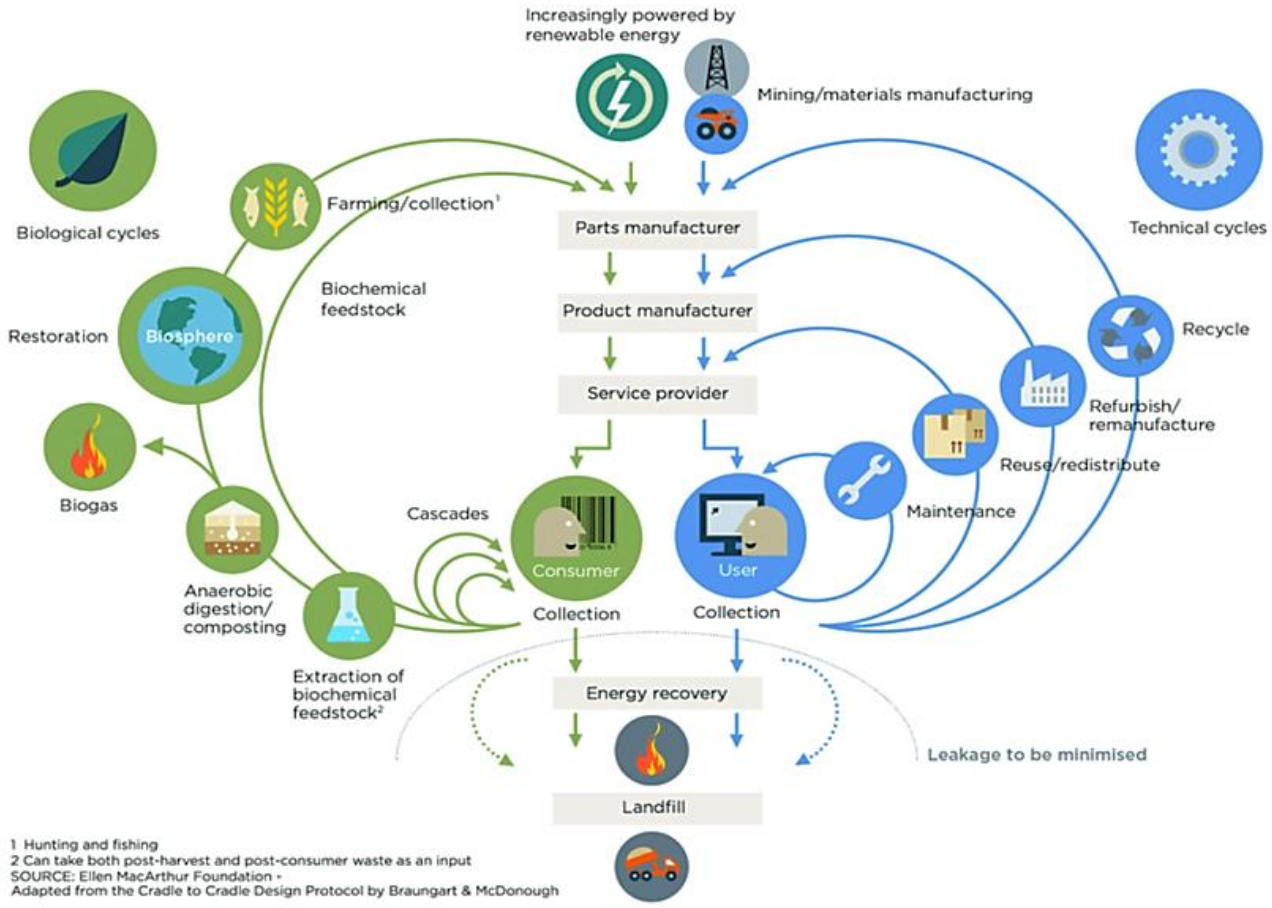

Figure 2.2 - Biological and technical cycles (see Ellen McArthur Foundation, 2013)

As it can be seen in figure 2.2, different ways to reduce waste of resources can be identified. In the biological cycle, the following methods can be used to regenerate renewable resources.

- *Anaerobic digestion:* process by which microorganisms break down biodegradable material to produce biogas that serves as an energy source and solid residuals that act as soil amendment. The process takes place in the absence of oxygen.
- *Composting:* process, in which organic material decays through microorganisms and is returned to the soil.

- *Cascading:* aims to maximize resource effectiveness by using materials and components as secondary resources in different value streams after their end-of-life.
- *Biochemical extraction:* process to produce low-volume but high-value chemical products while generating biomass and other value-adding by-products.

For technical components and goods, the following alternatives are available to extent their lifetime.

- *Reuse:* products are used again for the same purpose in its initial form or with minimal changes
- *Refurbishment:* reparation of damaged components to restore good working condition of products
- *Remanufacturing:* product components are recovered and built into new products
- *Recycling*: recovering materials for its original purpose or for a new one. Downcycling refers to the conversion to materials of lesser quality, while upcycling results in a higher material quality.

Moreover, there are methods that can be used for both cycles.

- *Energy recovery:* waste is used as sources for heat, electricity or fuel
- *Landfilling:* a site for the controlled disposal of waste in the ground

Additionally, the technical cycle should extend the principle of ownership into stewardship, in which a consumer turns into a user or creator. Consequently, new forms of contracts between businesses and customers, such as renting, leasing or sharing, have to be established. Furthermore, incentives to return products after their usable life should be created (Ellen McArthur Foundation, 2013; Stahel, 2010).

2.3.2 The importance of raw materials in circular economy

Today's megatrends such as global population growth, urbanization and decarbonization of transport rapidly increase the demand for raw materials. This trend is expected to continue, driven by increasing wealth and population in particular in developing regions like Asia. In 20 years, the world population will be 9.7 billion people. The steady increase of population will likely lead to a 100% increase of resource use between 2010 and 2030, challenging the secure supply of raw materials (European Commission, 2018).

With 3.4 million jobs and 206 billion euros of added values related to the raw material industries in the European Union, the secure supply of raw materials is of significant importance for Europe's economy (European Commission, 2018). At the same time, raw materials are critical enablers for change

as they are essential for industries like sustainable mobility, digitalization and renewable energies (Mathieux et al., 2017).

Today, the European Union is globally the third most important supplier of industrial minerals and the leading producer of mining equipment. However, Europe is still highly depended on the supply of critical materials from non-EU countries, for certain resources up to nearly 100% with China supplying 62% of critical raw material to the European Union (Pavel & Blagoeva , 2017). This is particularly critical, not only because it causes vulnerability in securing the supply of these materials, but also because the production in non-EU countries often have lower standards of governance, thus making a sustainable supply more difficult (European Commission, 2018).

To measure circular use of raw materials, the recycling's contribution, the recycling rate is a good indicator, which measures the percentage of material input derived from recycled materials. While recycling rates for certain materials in Europe such as construction waste are relatively high, the overall circular use is below 10%. Hindering factors are the lack of feasible technological solutions, unsuitable product designs and insufficient infrastructure (European Commission, 2018; Mathieux et al., 2017).

2.3.3 Value creation in the Circular Economy

The CE offers different sources of potential value creation. The value creation can significantly differ, depending on the type of product and company.

Accenture (2014) defines four areas of value creation, namely lasting resources, liquid markets, linked value chains and longer life cycles (see Figure 2.3).

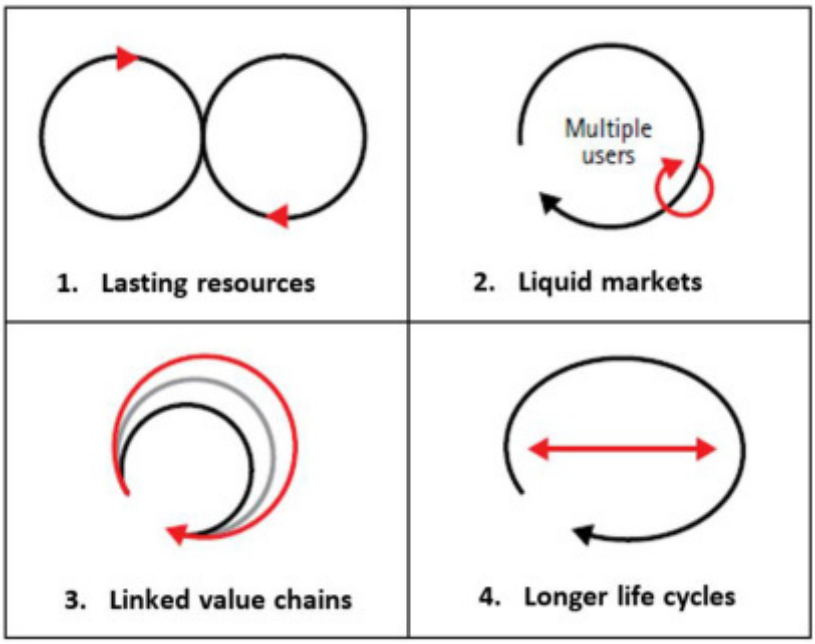

Figure 2.3 - Areas of value creation (see Accenture, 2014)

The first area proposes the use of resources that can be continuously regenerated such as renewable energy, thus creating efficiency and effectiveness. According to Accenture (2014), this principle can generate the highest potential value. The second area, liquid markets, emphasizes the importance of eliminating the idle time of products. Products and assets should be easily accessible and usable by different consumers. The third area of value creation focuses on preventing waste by reusing it in production. The last principle aims to expand the life cycle of products through product design, upgrading and remanufacturing.

The Ellen McArthur Foundation (2013) takes a similar approach. Referring to the foundation, value can be created through the power of the inner circle, the power of circling longer, the power of cascaded use and the power of pure inputs.

The power of the inner circle states, that the tightest circle should be chosen when recovering products and materials (compare Figure 2.2). As a result, value can be created through cost savings and higher virgin material substitution effects by minimizing waste along the process. In accordance with this concept, the Inertia Principle claims, that only the smallest possible part should be recovered to increase profitability: “Do not repair what is not broken, do not remanufacture something that can be repaired, do not recycle a product that can be remanufactured.” (Stahel, 2010, p. 195).

Referring to Stahel (2013), the smaller the loop, both geographically and activity-wise, the higher the value creation in terms of profitability and resource efficiency. The European Commission (2010) created a waste hierarchy that classifies material recovery strategies in terms of their value. As defined by the hierarchy, preventing waste, thus reducing the amount of waste produced in the first place should be the highest priority. The following option is reuse, thereafter, recycle and recovery. The least favoured option is landfill (see chapter 2.3.1).

The second source of value creation according to the Ellen McArthur Foundation, is the power of circling longer. This principle complies with Accenture’s principle of longer life cycles. A longer circling time can be achieved by either going through a sequence of cycles, or by extending the time spent in one cycle (Ellen McArthur Foundation, 2013). According to Stahel (2010), the product-life can be extended through reuse, repair, remanufacture and upgrading.

The power of cascaded use refers to the opportunity to use materials, products or components across different categories (Ellen McArthur Foundation, 2013). Cascading can be a tool to decrease the risk of uncertainty during a long-term utilisation of materials. Other strategies that fall into that category are cannibalising, in other words using spare parts of existing products, new products from waste or reusing disposed products for another function (Stahel, 2010).

The last source of value creation is the power of pure inputs. In order to exploit the potential of the previous mentioned sources, material streams should be pure and of high quality. This can be achieved by simplifying the separation of product components and by improving collection and transportation

processes, resulting in a less damaged goods and lower contamination rates (Ellen McArthur Foundation, 2013).

Van Renswoude (2015) adds two more sources of value creation to the definition of the Ellen McArthur Foundation: the power of dematerialized service and produce on demand. The former describes a shift from physical products to virtual service, resulting in resource savings and improved productivity. The latter states, that products should only be produced when demand is given. Stahel (2013) includes the value of continued ownership. Instead of selling a product, economic actors should sell the performance of a product, while retaining ownership throughout the whole lifecycle. Referring to the author, this strategy offers the highest material efficiency and profitability. By optimizing utilization, resource efficiency and competitive advantages can be exploited. Additionally, a higher product use intensity, for example through shared use, can create further value. This principle is equivalent to the second principle stated by Accenture, the liquid markets.

In order to enable value creation, circular principles have to be applied in each step of the material or product lifecycle.

2.4 Business models for the Circular Economy

A business model describes the principle of how a business creates, delivers and captures value. (Osterwalder & Pigneur, 2010). Circular business model innovation allow to rethink the value proposition and is therefore essential in the shift towards circular economy. The circular economy business model is defined by a model that creates value while operating in a closed loop. However, the loop does not need to be closed by one company alone, but rather through a supply chain network (Antikainen & Valkokari, 2016).

2.4.1 Innovation, components and typology

Radical innovation may be needed to implement a CE while at the same time remain profitable. Especially business model innovations play a key role in the realization of CE principles in business, where new value propositions have to be created. While 100% circular business models are not yet existent, innovation can enable the required change. It should be noted that a single business model does not need to close a loop by itself but could in fact create circularity by creating a system through the connection with additional business models (van Renswoude, 2015).

Different kinds of innovation could trigger the transition to new business models (OECD/Eurostad, 2018; Keeley et al., 2013; Potting et al., 2017):

- *Profit model innovation*: describes new ways of creating and capturing value.

- *Network innovation:* uses connection with other firms to share risks and assets, channels, processes or knowledge.
- *Structure innovation:* relates to a new way of organizing assets in order to create value
- *Business process innovation*: a new or significantly improved process for business functions that was implemented into the firm.
- *Product innovation*: refers to a completely new product or service introduced to the market.
- *Product system innovation*: products and services are bundled or connected through modularity, interoperability or integration, resulting in a robust system.
- *Service innovation:* improves and facilitates the utility of a product and therefore its value proposition. In CE service innovation should lead to a shift from ownership to selling the performance of a product, thus reducing resource consumption.
- *Channel innovation:* includes new channels through which you reach your customers and create value.
- *Customer engagement innovation:* aims to create a unique customer experience and build a connection between customers and the firm.
- *Core technology innovation:* new technology could shape or facilitate the transition to CE

Furthermore, socio-institutional change plays a major role in the implementation of CE principles. Socio-cultural changes would require a shift in rules, beliefs and customs, which could more radically result in new regulatory framework, cognitive structures and normative frameworks (Potting et al., 2017). The Ellen McArthur Foundation (2013a) also states that a paradigm shift towards system thinking will be necessary to enable the implementation of CE in businesses and societies. Similarly, van Renswoude (2015) notes that a systematic change is required to enable the transition to a CE, since the existing system is not suitable for the behavioural change. Not only process and product innovation but rather fundamentally new business models are needed to generate the desired economic and sustainability outcome (see figure 2.4). In this context, the relation between the three business levels have to be understood. In this process it should be analysed how the single components of a system influence each other and how the whole system impacts each component in a place and time.

System thinking can only be established by implementing inside-out (process-product-business model) and outside-in (business model-product-process) approaches. The inside-out approach allows an evaluation of business processes, while the outside-in approach can establish a vision for the business (van Renswoude, 2015).

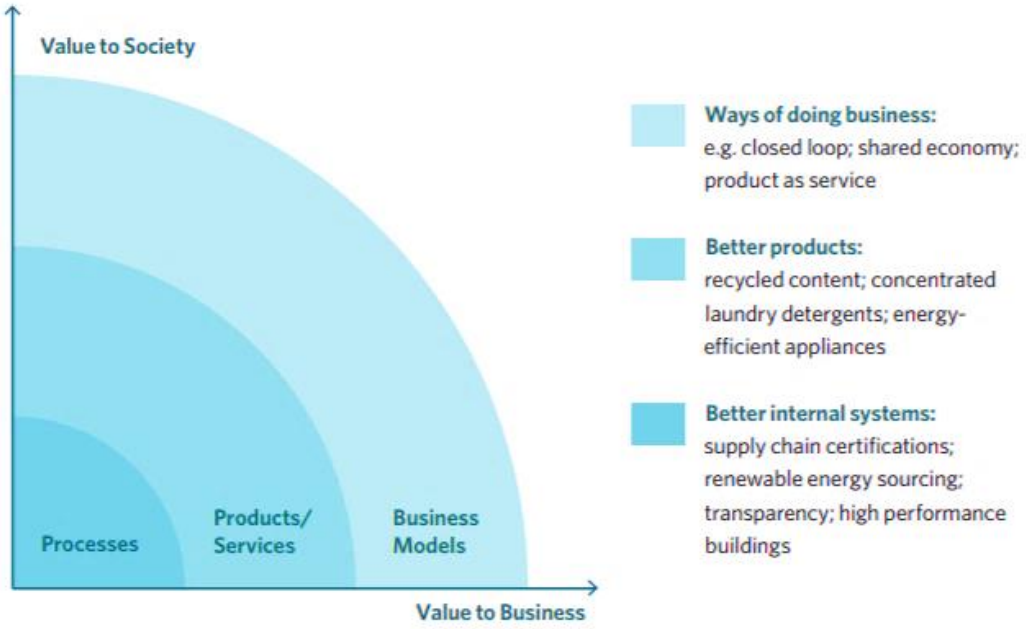

Figure 2.4 - Innovation Framework (see Clinton & Whisnant, 2014)

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Circular business models ideally show a set of characteristics. First of all, ownership of items should remain with the producer, thus encouraging a shift towards selling a performance rather than a product. Furthermore, functionality should be intended. As mentioned before, a circular business model should have a holistic system perspective, based on system thinking, considering internal and external circumstances. Also, it should hold social and organizational aspects, which corresponds to the aspired socio-cultural change. And finally, it should reduce resource consumption and waste production to a minimum (van Renswoude, 2015).

The Ellen McArthur Foundation (2015) introduced the RESOLVE framework, six business action for the transition to circularity. It serves as a tool for businesses to implement CE strategies and growth initiatives. RESOLVE stands for regenerate, share, optimise, loop, virtualise and exchange. Regenerate enforces the use of renewable energy and materials, the restoration of the ecosystem and the return of biological nutrients to the biosphere. Share focuses on decreasing the speed of loops by emphasising the shared use of assets, reuse, maintenance and upgrading methods. Optimise defines the increase in resource and product efficiency, the elimination of waste in production and supply chain and the implementation of big data automatization. This business action does not need a change in products or technology. Loop refers to the circulation of products and materials, preferably in the inner loops, through remanufacturing, recycling and anaerobic digestion. Virtualise emphasises dematerialisation by delivering utility directly or indirectly virtually. And lastly, exchange focuses on the replacement of old materials with advanced non-renewable materials, the application of new technologies and the introduction of new products or services.

Referring to Laubscher and Marinelli (2014) these actions can be integrated in six key business areas. The first area is the sales model, which aims to change the way of selling to customers. Instead of focusing on the volume of products sold, companies should shift to selling a service and provide incentives for customers to return products. The second area is the product design. Products should be designed with the intention to reuse the product, components or materials at a high quality after the end of their useful life. The next area to focus on is IT and data management. Traceability of products and materials throughout every step in the supply chain is essential to establish CE principles. It provides information about the reusability of products and their residual value. Furthermore, it facilitates the sorting of components and the implementation of return logistics. Supply loops are a further area to tackle, which refers to the recovery of products and materials and the use of recycled material. The next area is strategic sourcing for own operations. Trusted long-term relationships should be built with up- and downstream partners and co-creation be enforced. The last area is HR and incentives. In order to ensure the successful transition towards a circular business model, business culture has to be adapted and incentives for employees to change their mindset should be provided.

Based on these factors, building blocks for new circular business models can be defined. The Ellen McArthur Foundation (2013a) identified four building blocks of the CE: circular product design and production, new business models, skills in building cascades and enablers to improve cross-cycle and cross-sector performance.

Within the circular business model, Jonker at al. (2018) outlined five building blocks. First, cycles play a central role in the model. Circular entrepreneurship aims to build a circular model, in which materials, products and components are organized in loops. The second building block is the value creation. Value creation should build on the triple bottom line and create social, ecological and financial value. In this concept, a sustainable value creation is essential, rather than only closing a loop. The third building block is strategy. The strategy of circular business models deals with value creation through the delivery of added value during the lifetime of a product, instead of focusing on the point of sale. Therefore, long-term relationships with clients play a key role. The next building block is organisation. Coordination and cooperation within the supply chain are highly important in circular business models since one organisation alone will not be able to close an entire cycle. Consequently, the underlying organisation form has to promote a collective system. The last building block is the revenue model. Revenue generation in a circular model differs from generation in linear value chains, thus new suitable revenue models have to be developed.

Based on the outlined factors, a typology of circular business models was proposed in literature. The proposed business models should be discussed below.

2.4.2 Circular Economy Business Model patterns

Business models are built on a distinctive set of characteristics, also called patterns. Circular business models patterns can be defined according to their position in the product lifecycle. The product life cycle can be divided into three steps: production, consumption or use and end-of life. The figure 2.5 shows the seven circular business patterns that can be identified (Smith-Gillespie, 2017).

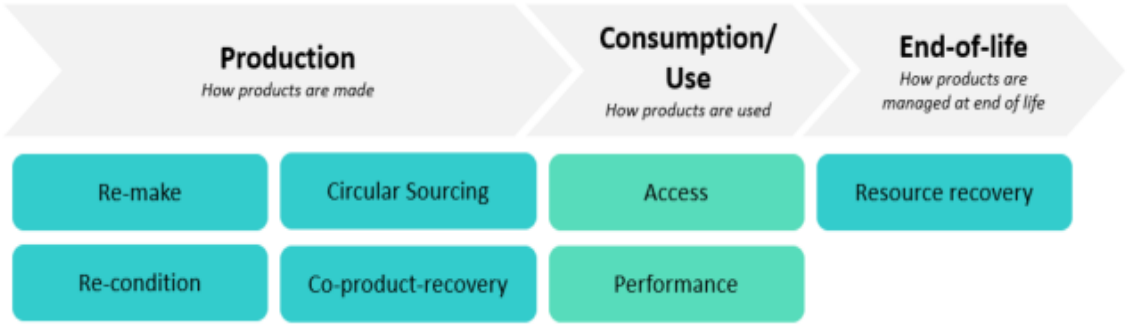

Figure 2.5 - Circular Business Model Patterns (see Smith-Gillespie, 2017)

In the production phase of the lifecycle four different business model patterns can be defined. Re-make describes the remanufacturing of a product at the end of its lifecycle in order to restore its performance as new or even above its initial level, with warranty to match. Re-condition outlines repair and refurbish actions with the aim to fix defective components or improve its aesthetic, without additional warranty on the whole product. Circular Sourcing refers to the sourcing of renewable or recycled resources that can be returned to the technical or biological cycle. Co-production recovery uses residual or secondary outputs from one process as input for another. In the consumption or use phase of a product two concepts can be identified that are not defining a pattern itself but are acting as enablers for business model patterns. End-users should be provided with access to the functionality of products instead of owing the products itself. Moreover, the focus should be the product performance, commonly provided as a product-service bundle (Smith-Gillespie, 2017).

In the last stage of the product lifecycle, the end-of-life phase, one pattern can be characterized. Resource recovery describes the act of reintegrating resources into the process or to incorporate them into other products. Based on the defined business model patterns, different types of circular business models can be created.

2.4.3 Circular Business Model Elements and Types

Generally, business models should be examined in terms of value proposition, value creation and delivery and value capture. According to Bocken et al. (2016) four types of circular business models can be distinguished: access and performance models, extending product value, classic long-life models and sufficiency.

The access and performance model creates the value proposition for the customer through service provision rather than selling ownership of a product. Value creation and delivery are the responsibility of the manufacturer or retailer. The circularity in this case offers opportunities for financial benefits since additional revenue can be generated by product life extension. Value capture is achieved through pricing each service unit. The access and performance strategy can potentially decrease the needed amount of physical goods and provide incentives for slowing resource loops. Manufacturers can benefit from higher profits while users could be motivated to slow resource loops through decreased costs when the use is reduced. Examples for such a business model are care sharing or phone leasing.

The extending product value business model is focused on the exploitation of the residual value of products. Remanufacturing operations should aim to recover products without the need of new net material consumption. The value proposition is based on the exploitation of the residual product value through manufacturers who in return are able to offer affordable as-new products to customers by recovering products through remanufacturing or repair. Value creation and delivery focuses on incentives for product returns through take-back actions and collaborations with retailers and collection points. Value is captured through the reduction of material costs, thus resulting in lower overall costs.

The classic long-life model focuses on a long product lifecycle that can be supported by designing products for durability and repairing. High-quality long-lasting products in combination with a high service form the value proposition. Similarly, the value creation and delivery is based on long-lasting product design and a high customer service.

Sufficiency is also based on durable products. But in contrast to the classic long-life model, the sufficiency model follows a non-consumerist approach to sales and promotion, thus no over-selling or sales commission. By designing long-lasting products and offering a high customer service level, the concept strives to lower end-user consumption. Similarly to the classic long-life model, the value proposition are high quality, long-lasting products and a high service level. Value is created and delivered through selling high-end products, rather than products with a built-in obsolescence. Since the model is based on high quality high-end products, value can be captured through higher margins even though products are sold slower. Additionally, customer loyalty can be created (Bocken, et al., 2016).

This typology is commonly shared in literature. Accenture (2014) identified five business models in a study among over 120 companies: Circular Supplies, Resource Recovery, Product Life Extension, Sharing Platform and Product as a Service. These business models focus on different stages in the supply

chain and can be implemented on their own or in combination with other business models (see figure 2.6).

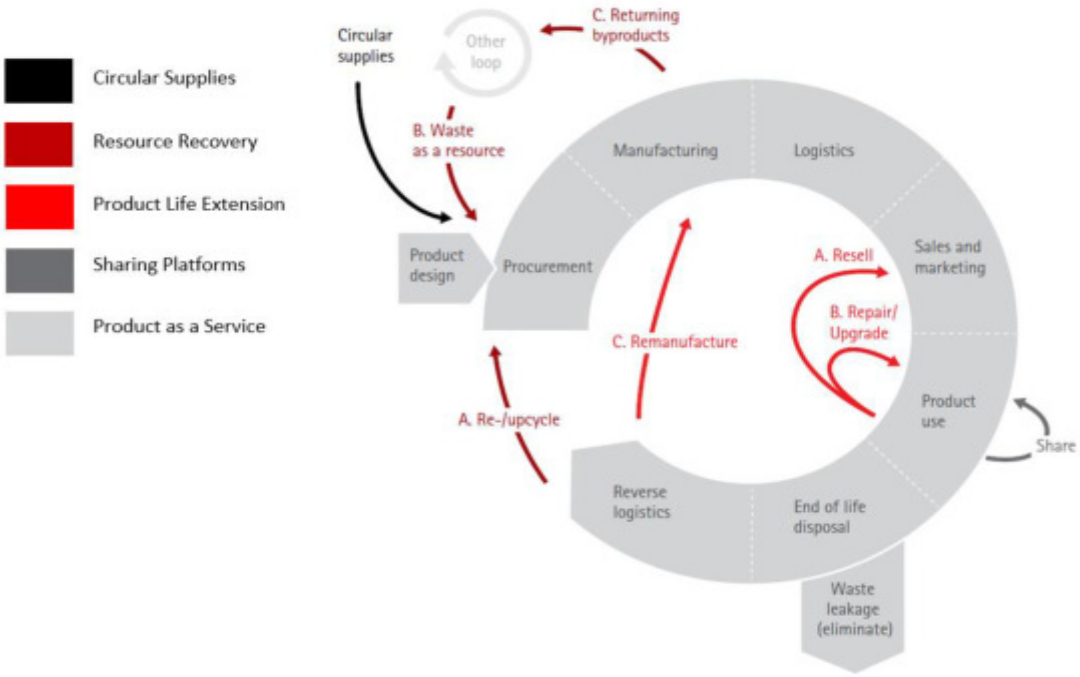

Figure 2.6 - Business Models (see Accenture, 2014)

Circular Supplies targets to replace the linear resource approach with the use of renewable inputs for circular production and consumption. By following that approach, companies could benefit from a decrease in waste and lower inefficiencies. Circular Supplies is the model that has the highest impact on companies that operate with scarce resources or those who have a significant environmental footprint.

Resource Recovery is comparable to the extending product value model. Through recycling and upcycling services, the embedded value of products can be recovered at the same or even above the level of the initial investment. Therefore, the model is the most suitable one for companies that deal with large volumes of by-products and businesses that could recover waste cost efficiently.

Similarly to the approach described by Bocken et al. (2016) Product Life Extension focuses on extending the lifecycle of products and as a result the value of the products can be recovered and even additional revenue can be generated. Businesses with capital intensive B2B segments, such as B2C companies that deal with pre-owned products should consider this type of model.

Sharing Platforms promote the collaboration between product users and the shared use of products to maximize utilisation, productivity and user value creation. While the model initially targets companies with products that have a low utilization or ownership rate, the model is nowadays often adopted by businesses that specialize in offering shared services rather than producing anything themselves, putting manufacturers under pressure.

Product as a Service follows a similar approach as the Access and Performance Model. Instead of focusing on ownership of products, the model proposes leasing or pay-for-use arrangements and shifts the focus towards performance rather than volume. The model also triggers a change in mindset. Long lifecycles, reusability and shared use of products are no longer recognised as cannibalization risks, but as drivers for costs reductions and revenue growth. The model would be most suitable for companies that produces products with a high cost of operation share and that have the necessary maintenance skills (Accenture, 2014).

In addition to the already mentioned models, Bakker et al. (2014) defined two additional models: The Hybrid-Model and the Gap-Exploiter-Model. The former describes a model that combines long-life components with short-used biodegradable components, as it is the case for printers with exchangeable ink cartridges. The latter focuses on products with components that differ in terms of their useable lifetime. This offers the opportunity for businesses to offer additional substitute products and services that allow the prolongation of the product lifecycle.

KPMG (2018) defined three categories of business models: Circular Input Models, Circular Use Models and Circular Output Models.

Circular Input Models tackle the input side in the supply chain, i.e. production processes and resources used. Besides the already discussed models Circular Supplies and Long lifetime, the Circular Input models propose to focus on process design, thus designing processes that support the reusability and recyclability of products, by-products and waste. Also, it should be focused on product design by designing products that are intended to last long or to be recovered.

Circular Use Models focus on the phase of use and aims to maximize the utility of the product as well as retaining its value. The models are based on reverse logistics and offer alternative approaches to ownership. Additionally to the models Product as a Service and Sharing Platforms, Tracing Facility and Circular Leasing/Buy Back are introduced. Tracing Facility provides services to track and deal secondary raw materials. Circular Leasing/repurchasing agreements and sell and buy back is a model that focuses on return services for products.

The last category, Circular Output Models, puts emphasis on the after-use phase by creating new value through transformed products after their useful life. Again reverse logistics plays a key role for these models. Five output models can be identified. Reuse/redistribute/recaptures suppliers focuses on selling used products or materials to reduce the use of virgin material. Support Lifecycle extents the product lifecycle by selling spare parts or add-ons. Refurbish and maintain offers recovered products for sale. Recovery providers offer take-back systems and collection services, recovering useful parts from disposed products. And finally, Recycling facilities creates value by recovering waste.

The WRAP Business Model Map distinguishes between five categories of business models: Service Systems, Hire and Leasing, Incentivised return, Re-use and Long life. Service Systems include Product

Service Systems, which comply with Product as a Service, and dematerialised services that provide services without a physical product through collaboration and sharing, resulting in a shift in consumption patterns. Hire and Leasing model is similar to the access and performance model, providing short- or long-term rental and leasing in B2C or peer to peer agreements.

Incentive return includes collaborative consumption, which enables shared access to products and services and incentivised return and re-use that supports the return of used products which then can be re-used and refurbished. Re-use comprises two models: asset management, the collection, refurbishment, re-sale of used products and reducing consumption. Long life relates to a product design that promotes a long lifecycle, thus reducing consumption (WRAP, 2019).

2.4.4 Business modelling tools and value proposition

Value plays a key role in every business model. It can be distinguished between value creation, which describes how value is created and delivered, value proposition, thus the value that is offered to the stakeholders by the company and value capture, so how the company generates value i.e. in the form of revenue (Richardson, 2008). Business model innovation concentrates on re-thinking the value proposition and developing new ways of value creation (Bocken, et al., 2013). Circular business models do not only have to consider economic value, but also integrate sustainable value into their business model.

Business modelling tools provide a framework to generate business model innovations and to assess existing business models. A widely used generic tool in this context is the business model canvas, which describes a business model through nine building blocks: customer segment, value proposition, channels, customer relationship, revenue stream, key resources, key activities, key partnerships and cost structure (Antikainen & Valkokari, 2016; Osterwalder & Pigneur, 2010).

Based on the business model canvas Joyce and Paquin (2016) developed a sustainable business canvas, the so called triple layered business model canvas, which evaluates besides economic, also environmental and social value. By integrating the two additional layers into the original canvas, the model provides horizontal coherence by exploring the different types of value creation individually, thus supporting a broader system thinking and vertical coherence by aligning actions and interconnections between the three value layers, enabling to deeper understand the value creation of a business. The environmental layer is built on a life-cycle-assessment, which evaluates the environmental impact of an organization's business model, including products and services, throughout the different lifetime stages. Depending on the type of business, the environmental impact can be assessed across different indicators, such as water use, human health or eco-system quality. In a sustainable business model, the environmental benefits should outweigh the environmental impact. By evaluating the business model in the environmental layer it can also reveal potential areas for environmentally focused innovations.

Nine components are defined in the environmental layer: the functional value, materials, production, supplies and outsourcing, distribution, use phase, end-of-life, environmental impact and environmental benefit. The social layer of the triple layered business model canvas focuses on stakeholder management, which and aims to consider the interests of the stakeholders rather than operating only profit oriented. Thereby, the influence between the different stakeholders and the organizations are evaluated in order to assess the key social impact. Stakeholders can be defined as the groups who are influenced or influence the decisions of a business. The most relevant stakeholder groups are normally represented by customers, employees, shareholders, the government, suppliers and other interest groups and communities. The social layer provides insight into the organization's social impact and possibilities for social value creation. Similarly to the environmental layer, the social layer comprises nine components: social value, employees, governance, communities, societal culture, scale of outreach, end-users, social impact and social benefit (Joyce & Paquin, 2016).

Bocken et al. (2013) also developed a tool that is based on a multi-stakeholder approach, the value mapping tool. According to the authors, a sustainable business model should explore different types of value for a broader range of stakeholder. Sustainable business models have the potential to create competitive advantage through superior value proposition while simultaneously supporting sustainable development. In contrast to conventional business models, that focus on value in use and transaction value, sustainable business models apply a more holistic approach to value proposition. The value mapping tool proposes four different types of value. The value proposition founds the base of the business model and is defined as the value that is offered to the stakeholders. Value destroyed captured the negative social and environmental impact of an organization. Missed value opportunities describe the situations in which value is not fully utilized by the stakeholders of the network due to inappropriate designed value creation or capture systems, lack in best practice, or failure to recognize value. New value opportunities include opportunities for new markets, products or services that offer superior value to stakeholders.

The value mapping tool offers a framework to assess potentials for new value propositions. It provides a network centric perspective by considering each of the stakeholder groups individually. The stakeholder groups identified are the environment, society, customers and network actors. Furthermore, the tool maps each of the four types of value to enable a systematic value assessment (see figure 2.7).

Therefore, the tool promotes the integration of sustainability into the core of the business model by giving a deeper insight into the value proposition and the value network. The tool can also identify conflicting values and provide solutions for better alignment if stakeholder interests. Environmental and social impact of the business model can be reduced and benefits for both, the stakeholders and the organization can be created (Bocken, et al., 2013).

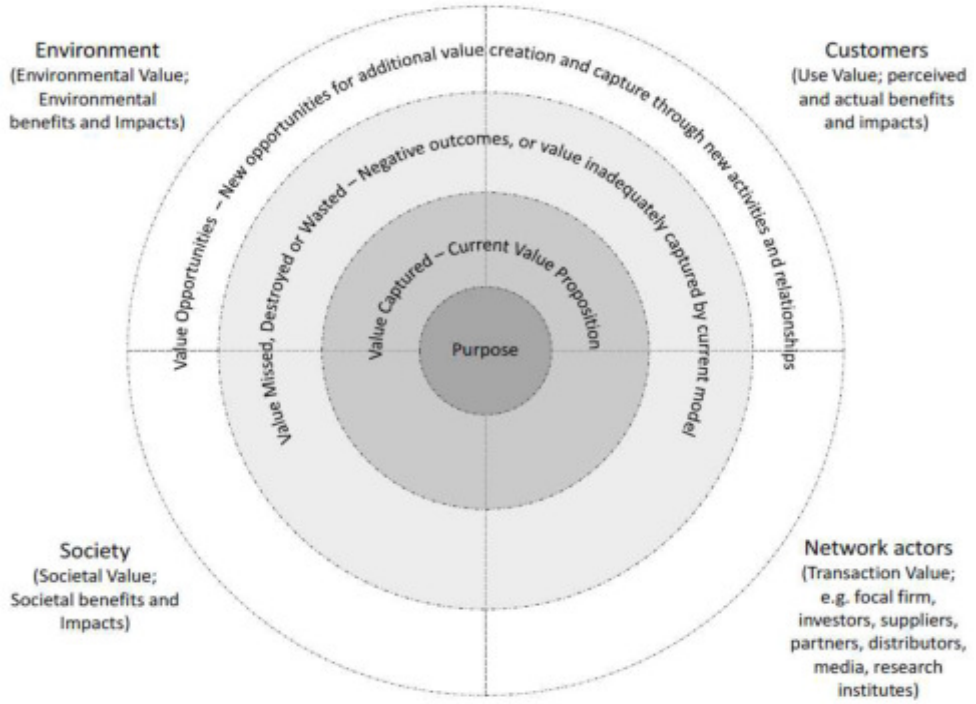

Figure 2.7 - Value Mapping (see Bocken et al.,2013)

Circular business models are expected to create better economic, environmental, and societal outcome. The Ellen McArthur Foundation in cooperation with the McKinsey Center for Business and Environment (2015) investigated the anticipated development in a circular scenario. With regards to the economic outcome, households would especially benefit from reduced costs for products and services, resulting in an increase of the disposal income of an average European income by 18% by 2030, compared to 7% under the current scenario. By 2050 the difference would be even more significant with 44% of growth in a circular model compared to 24% in the linear counterpart. The increase in income would lead to a higher consumption and thereby a growth in GDP. Industry observations underpin this prognosis. Innovative companies that are already operating circular show a positive outcome, benefitting from reduced energy consumption and waste while at the same time retaining value.

Besides an improvement in economic indicator, the circular scenario also predicts positive environmental impact. Circular business models could significantly reduce Europe's consumption of virgin material as well as decrease emissions. In the mobility, the food and the built environment sector CO2 emissions could be cut by 53% by 2050 compared to 2012. Furthermore, circular development is likely to improve air quality and reduce noise pollution, thus improving the overall quality of life. In addition, the circular economy is expected to positively influence labour demand and encourage a shift from the labour scarce raw material sector to the labour-intensive recycling sector (Ellen McArthur Foundation & McKinsey Center for Business and Environment, 2015).

However, circular business models do not only provide benefits for external parties, but also for the business itself. Circular business models can expand existing markets or even enable the company to enter new markets, thus increase market share. By extending the lifecycle, an alternative to new products for additional customer segments can be offered. The new green image of the company can also attract new sustainability-oriented customers and thereby creating additional revenue streams. Moreover, new business models, such as product-as-a-service, can change the way businesses meet customer demand. These business models can also increase customer loyalty and stabilize revenue streams since the company retains ownership and maintains long-term relationships with existing customers. Long-term relationships also create trust, which provides possibilities for collaboration and improved customer value. Furthermore, it can help to receive better feedback on products or services offered. Circular business models can also trigger innovations, both in product design and business models, driven by new possibilities of value creation. By eliminating waste and reducing the use of virgin material, companies can save costs while reducing the risk of volatile prices and supplier dependencies. At the same time, by operating circular businesses can meet the rising public expectations in terms of sustainability. Overall, the adaptation of the previously mentioned aspects can help a company to create a competitive advantage (PACE, 2019; KPMG, 2018; van Renswoude, 2015).

3 Market analysis

3.1 Circular economy in Europe's SMEs

SMEs in Europe are defined as companies with less than 250 employees and a turnover under €50 million (European Commission, 2020b). With 99.8 % of Europe's companies being SMEs, it is important to assess the enablers and barriers that could promote or prevent the transition to Circular Economy (European Commission, 2019a).

3.1.1 Enablers and barriers for SMEs

SMEs are becoming increasingly aware of sustainability concerns and the positive impact of operating resource efficient. However, small companies tend to be reactive rather than proactive to environmental issues, since they often lack to link environmental practices to profit (Ormazabal et al., 2018). Saving materials, creating a competitive advantage and expanding to new markets act as the main drivers for European SMEs to take measures (Rizos et al., 2016). An implemented environmental management is the foundation for the transition to a circular business model, exceptions may be start-ups that were founded on circular principles (Ormazaba, et al., 2018). Furthermore, the corporate culture represents one of the most important enablers for the progress towards circularity. Mindset and commitment of all hierarchy levels in a business are crucial. Again, start-ups may have an advantage in this aspect since they can build a circular mindset from the start. Additionally, knowledge about circular principles from existing employees can be considered helpful. Another enabler is networking, which relates to partnerships in the supply chain, as well as to connections with other SMEs that strive for circularity. Moreover, companies are more motivated to adopt a circular business model when it aligns to their customers' preferences. Financial incentives in the form of circular business funds and low risks of investment are additional enablers. External recognition, prices and awards also act as a driver, as well as government support (Rizos et al., 2016).

Besides enablers, there are also many barriers that SMEs might face during the transition to a circular business model. De Jesus and Mendonça (2018) differentiate between hard barriers and soft barriers, whereby hard barriers refer to technical and economic, market and financial factors and soft barriers include institutional and social factors. Technology is a key requirement for the successful transition to CE. Especially SMEs depend on the available technology in the market since they do not have the means to finance the development of their own circular technology. Technologies are needed to optimize the product lifecycle and to analyse the reuse of materials and by-products. Furthermore, information and communication technologies are important in the CE (de Jesus & Mendonça, 2018). However, not only the technology itself, but also the necessary technical and technological know-how can be a barrier for SMEs. Up to today, linear technology is still dominating the market. The

transformation from a linear to a circular business model, would require the integration of sustainable production and consumption technology into the exiting linear model and skilled managers and employees to lead the transformation (Rizos et al., 2016). Many SMEs do not have the necessary capacities and know-how to assess and implement advanced technologies. As a consequence they keep relying on the linear business models and technologies, which they are familiar with. Moreover, they rely on their suppliers' technical solutions (Rizos et al., 2015).

Economic, market and financial factors represent the second hard barrier. SMEs face obstacles in financing the transition to CE. The transformation from a linear to a circular business model can require high initial investments. Smaller businesses not only often lack the necessary initial capital, but usually also have a higher cost sensitivity and are more dependent on the pay-back period of their investments. Besides the direct investment, indirect financial costs, such as time and human resources are a burden for SMEs (Rizos et al., 2015). Despite the increasing effort to offer European funds, SMEs often have difficulties to find suitable financial help. Traditional bank loans are not willing to comply with occasional delays in the payment of an instalment, which might be required by SMEs. Furthermore, bankers still seem to be critical about the commercial benefits of circular models (Rizos et al., 2016). Missing learning curves and experience with circular business models, thus high required investment in learning represent another market barrier. Moreover, low virgin material prices in many industries are still barriers to switch from a linear to a circular model (Kirchherr et al., 2018). Additional challenges are the customers' acceptance of product-as-a-service systems and legal problems of retaining ownership as a company. Circular models also face challenges in establishing take-back systems with partners and quality standards for refurbished products (Govindan & Hasanagic, 2018).

The soft barriers, institutional and regulatory factors, as defined by de Jesus and Mendonça (2018) are one of the most significant limiting factors in the diffusion to CE. Government support, such as offered funds, education set-ups, suitable taxation policies and import duties can promote the development of circular business models. However, the absence of an appropriate legislative framework could not only hinder the transition, but could also strengthen the exiting linear paradigm (de Jesus & Mendonça, 2018). As mentioned before, the low costs of virgin materials hinder companies to change their exiting linear system. The low costs are a consequence of subsidized energy rates, thus existing governmental subsidies could undermine the implementation of CE (Kirchherr et al., 2018).

The lack of a strict legal system highly influences SMEs, since they are more affected by regulators and local authorities than bigger companies. Moreover, there are not sufficient standard systems for performance assessment, including standard key performance indicators. In particular SMEs are lacking suitable tools since the majority of environmental management tools are developed for larger companies (Govindan & Hasanagic, 2018; Rizos et al., 2015).

Social and cultural factors represent another soft barrier. Trends, such as social awareness of environmental problems and shifting consumer preferences can drive the transition to green business

models. But consumer habits and business cultures are only changing slowly. A lack of interest and awareness, as well as insufficient investment in the education of consumers is considered a key gap (de Jesus & Mendonça, 2018). In addition to the demand-side, a hesitant company culture is a core barrier in the transition to circular business models. Circular business models require the integration of the concept into the strategy, mission, vision, goals and key performance indicators and companies often fail in the holistic adaptation. Moreover, a lack of cooperation in the value chain and the focus on cost drivers in procurement are limiting the implementation of circular practices (Kirchherr et al., 2018).

Cultural barriers are also a critical factor for SMEs. Although SMEs are generally very heterogenous entities, they show similarities in terms of organizational structure and management regime. Often the manager of a SME is also the owners of the business. Therefore, their attitude towards sustainable business is crucial and can hinder the transition remarkably (Rizos et al., 2015).

Furthermore, there are not enough successful circular business models and frameworks available. Companies that outsource their production to low wage countries, as it is common practice in developed nations, need guidelines in the management of sub suppliers and the generation of waste (Govindan & Hasanagic, 2018).

3.1.2 EU regulations and support

Government regulations play an important role in the transformation to a circular economy. In 2015, the European Commission adopted the Circular Economy Action Plan, which included 54 actions with the goal to improve employment, growth and investment and to develop an economy that is resource-efficient, yet competitive. The action plan measured different areas of action, such as product design, production processes, consumption, secondary raw materials, as well as innovation and investment. In March 2019, the European Commission declared the action plan with all its 54 actions as completed (European Commission, 2019b).

In March 2020, a new Circular Economy Action Plan was published as part of the European Green Deal that aims to decouple economic growth from resource use. The new action plan builds on the achievements since 2015 and focuses on the design and production for the transition to a fully circular economy. While the actions since 2015 mainly targeted the supply side, the new action plan acknowledges the need for new ways of consumption (Pantzar & Suljada, 2020).

Small and Medium-Sized Enterprises play a key role in the transition to a circular economy in Europe. Therefore, the European Commission established support systems such as the Enterprise Europe Network and the European Resource-Efficiency Knowledge Center to help SMEs to operate more resource efficient and to improve their production processes. Furthermore, a pan-European network has been created which is working on a knowledge base for substitutions of hazardous substances. SMEs that develop innovative technologies can also demonstrate their performance and gain credibility in new

markets within the Environmental Technology Verification pilot programme (European Commission, 2019b).

The new action plan will continue to strengthen the role of SMEs by encouraging collaboration and knowledge sharing and by providing necessary funds.

Furthermore, in order to provide incentives for companies to adapt circular policies rather than the take-make-dispose pattern, the new action plan proposes a sustainable product policy legislative initiative. Within the initiative, the eco-design framework should be widened to be applicable for a broader range of products. Sustainability regulations should also be adapted addressing the durability, reusability, upgradability and reparability of products.

Moreover, a mindset shift relating to ownership should be triggered by promoting alternative models such as products-as-a-service (see chapter 2.4).

Primary focus product groups of the new action plan are textile, electronics, as well as construction elements such as cement and steel (European Commission, 2020a).

3.1.3 Plans and actions in Portugal

In 2014 the Portuguese government, in collaboration with 100 organisations, established the green growth agenda which states a long-term economic strategy for the country. The agenda puts emphasis on circular economy policies and aims for sustainable growth to recover from the financial crisis 2007-2008. In 2012, around 57,000 jobs in Portugal were related to the circular economy, with a potential job creation of 36,000 additional jobs by 2030. The objectives of the plan include promoting renewable energies, reducing waste and increasing water and energy efficiency. To reach these goals a clear framework was established which involved stakeholders early on (Portuguese Ministry of Environment, 2015).

Based on the European Action plan, Portugal developed a circular economy roadmap which was published in 2017. The roadmap includes policy changed objectives within four focus areas:

- **A carbon neutral economy**: aiming for an efficient use of resources, the reduction of waste and a significant cut in emissions
- **Knowledge as impulse:** put emphasis on research and innovations to benefit from new business models, job creation and changes in resource consumption
- **Inclusive and resilient economic prosperity:** targeting all sectors to decouple economic growth from negative environmental and social impacts
- **A flourishing, responsible, dynamic and inclusive society:** encourage and enable the society to act collaborative and trigger a shift in consumerism (Ministry of Environment Portugal, 2017)

In addition to the plan on a national level, regional and local actions are encouraged. The plan also targets SMEs as they can benefit from tax incentives for research and innovation in the field of circular economy.

In 2018, the first effects could be noticed, with actions taken across the country, promoted by local communities, NGOs and business associations. In general, Portugal shows great efforts in transitioning into a more circular economy, both political as well as in private actions. A main driver is Portugal's wide range of natural resources. The country was also the first EU member banning single-use fossil-based plastic products. Despite its efforts, Portugal still has room for improvement with regard to the circular economy. In the circular economy performance ranking of European Union member states, Portugal is positioned in the middle. Although there is no clearly defined indicator to measure the maturity of a country's circular economy, the metabolism of an economy allows conclusions to be drawn.

Portugal's economy is indicated by a relatively slow metabolism. The country's material productivity is developing slower than the European average, meaning the country consumes more materials than material generated by the Portuguese economy. While in 2005 Portugal's material productivity was at the same level as that of Spain or Ireland, the Portuguese indicator improved by only 23% by 2015, compared to the European Union by 30% and Spain by 134%. Furthermore, Portugal is lacking behind in terms of water use efficiency, which indicates the waste or efficient reuse of water. Additionally, Portugal could improve its municipal waste recycling rate as well as its investment in the private sector. Further, public awareness could need improvement (Ministry of Environment Portugal, 2017).

3.2 The ornament stone industry in the Circular Economy world

The ornament stone industry is defined as the primary sector that revolves around the extraction and processing of natural ornament stone. Products of the ornament stone industry include sandstone, granite, marble, and dimension stone. Being one of the oldest industries in the world, the extraction and processing of ornament stone plays an important role in many countries including Portugal (Chambel, 2016).

3.2.1 Mineral requirements of a modern society

The demand for raw materials including biomass, fossil fuels, metallic and non-metallic material such as natural stone is steadily increasing in the past decades (see figure 3.1). And the trend is expected to continue.

Given the growing world population and the increase in consumption, non-metallic material extraction is said to experience a sharp increase of 168% by 2050 (European Commission, 2018)

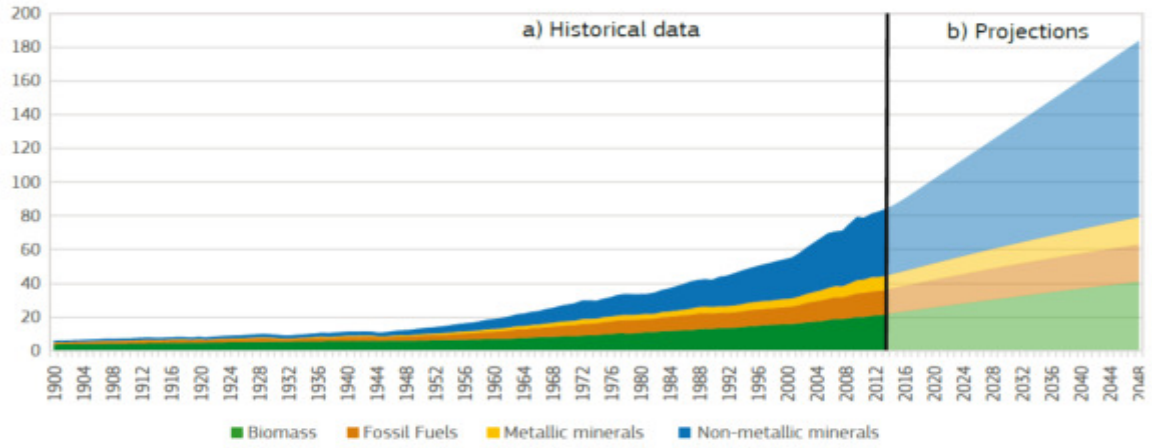

Figure 3.1 - Development of global raw material extraction (see European Commission, 2018)

The raw material industry that is dominating in Portugal's economy is the manufacturing of non-metallic mineral products (see figure 3.2). However, Portugal does not yet reach its full potential in the extraction of raw materials. It is estimated that national geological resources in Portugal could account to the value of the gross domestic product. Natural resources in Portugal include metal ores, ornament stones, industrial minerals, and industrial rocks (European Commission, 2015).

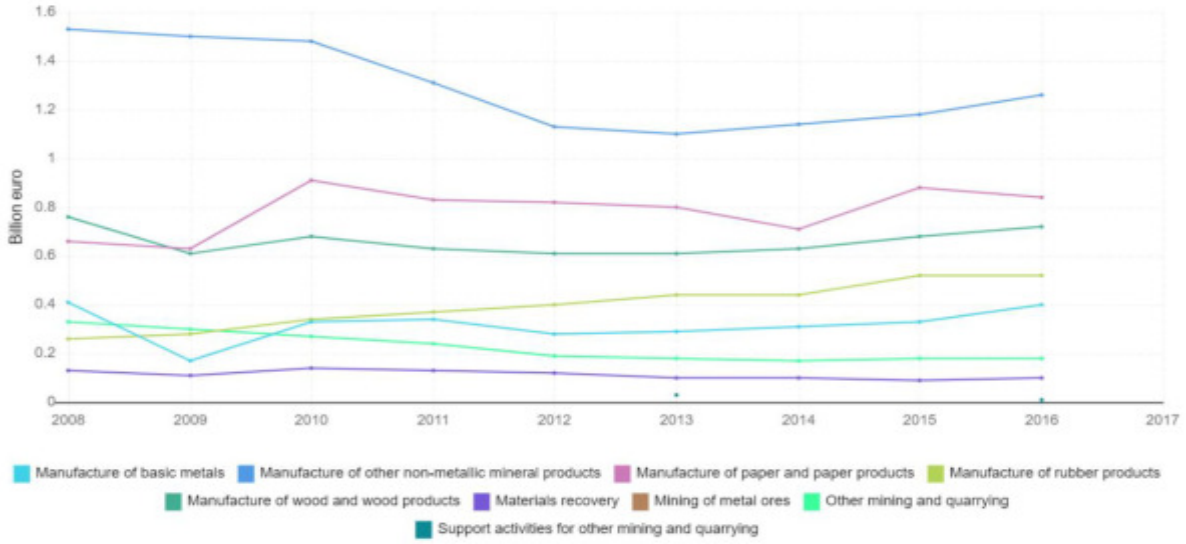

Figure 3.2 - Value added at factor cost in raw materials sectors in Portugal (see European Commission, 2020)

3.2.2 The ornament stone industry in the European Union and Portugal

Portugal is one of the largest world exporters for natural ornament stone. In the South and Centre of Portugal mainly marble, and limestone are mined, while the Centre and North is predominantly concerned with the extraction of granites (Chambel, 2016).

The natural ornament stone products extracted in Portugal have different characteristics. Marble is a rock contained from limestone or dolomite. Usually Marble is found in large deposits and can therefore be economically mined on a large scale. The extracted stones are manufactured into crushed stone or dimension stone. Since it is easy to carve, marble is used in a variety of products such as ornament stones and sculptures.

Limestone is an organic sedimentary rock and is mainly formed on the sea floor through the accumulation of organic, chemical, or detrital calcareous materials. Extracted limestone is usually impure and contains other materials like sand, silt, or mud. It is widely used in construction where it is manufactured to cement and mortar or added to paint or roofing tar. Furthermore, it is utilized in the construction of roadways and asphalt concreted. In agriculture, limestone powder is used to improve soil quality by neutralizing acid soils. Additionally, limestone can be found in a wide variety of products like plastics, tiles or toothpaste where it is added as white pigment or cheap filler.

Granite is the most common intrusive rock formed under the earth's surface through the crystallization of magma. Therefore it occurs in large deposits on every continent. Granite is being quarried through cutting or spraying operations and is then manufactured into tiles, floors, stairs or monuments (Geologyscience, 2020). Not only the extraction, but also the manufacturing of stone such as ornament stone is done in Portugal, with factories close to Lisbon. Additionally, the country produces equipment and machinery applied in the stone industry (Chambel, 2016).

During the financial crisis, the ornament stone industry in Portugal faced major challenges because of a sharp decrease in construction. However, the ornament stone industry managed to recover, also supported by the increased construction of hotels since tourism is booming in cities like Lisbon (Litosonline, 2019). Due to its geographical location and its historic experience in the industry, Portugal benefits from a competitive transport infrastructure as well as specialized manpower for trade with Europe, Africa and America.

The ornament stone industry in Portugal consists mainly of small and medium sized, family-owned businesses. Therefore, policies to introduce circular business models in the ornament stone industry should be designed particularly for SMEs. Furthermore, the involvement of stakeholders plays an important role as their choice of product influences product design and services (Chambel, 2016). For knowledge sharing, promotion of R&D and collaboration between different sectors, the Portugal Mineral Resources Cluster was founded with members from academics and industry (Cluster Portugal

Mineral Resources , 2020). StonePT – the Portuguese stone brand, was created through a partnership between ASSIMAGRA (Associação Portuguesa dos Industriais de Mármores, Granitos e Ramos Afins) and IST (Instituto Superior Técnico) and provides a certifcation system that ensures the high standards of Portuguese natural stone in terms of quality of the products, process management and proof of origin (StonePT, 2020).

3.2.3 Circular Economy in ornament stone industry

Waste management in the ornament stone industry pose environmental as well as economic problems. Waste is produced through different activities throughout the production chain of natural ornament stone. First of all, there is waste in natural ornament stone deposits, such as rubble or stones that are unshaped and therefore unsuitable for building purposes due to their shape. Furthermore, ornament stone processing produces waste in the form of scrap material coming from sawing and cutting the stones. Many technology innovations led already to a reduction in waste coming from the various process steps, however it is inevitable to eliminate waste production completely. Therefore, alternatives to reuse by-products should be found (Careddu, 2019).

In 2008, the European Union launched the Raw Materials Initiative (RMI), a strategy that aims to address the issues of sustainable raw material sourcing and production as well as resource efficiency and sustainable supply. One of the main drivers for the initiative was the importance of raw materials for the European industries with a minimum of 30 million jobs relying on the availability of raw materials. The second cornerstone of the European raw material strategy is the European innovation partnership (EIP) introduced in 2012. The European innovation partnership aims to connect European stakeholders such as representatives from industry, academia and NGOs on a platform to share knowledge and encourage innovations (European Commission, 2020b).

As part of the EIP a Raw Material Scoreboard was developed that provides an insight into the key challenges associated with raw materials across the entire value chain (see figure 3.3). The scorecard provides monitoring information to all stakeholders in accordance with the overall objectives of the EIP. In 2018 the second edition of the scorecard was being published with updates expected every two years. The second edition of the scorecard covers five main clusters:1) Competitiveness and innovation, 2) Framework conditions for mining, 3) Circular economy and recycling, 4) Environmental and social sustainability. For each cluster, detailed indicators have been defined.

To develop the presented indicators, collected data is tested against the RACER criteria to confirm that they are relevant, accepted, credible, easy to compute and understand and robust. The identified indicators provide a guideline towards the fulfilment of sustainable development goals and should be considered when developing a circular business model for the natural ornament stone industry in Portugal (European Commission, 2018).

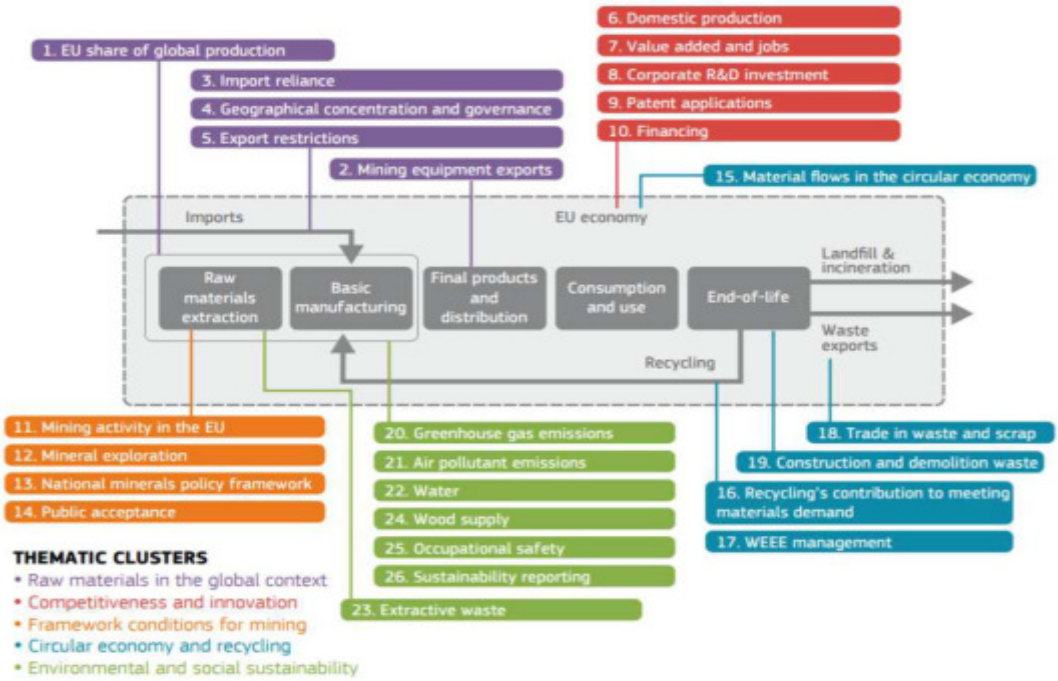

Figure 3.3 - Raw Material Scoreboard (see European Commission, 2018)

3.2.4 Circular business models and actions for the ornament stone industry in Portugal

Potential circular business models for companies in the natural ornament stone industry have to consider the size of the organization, as well as the particular extraction and processing procedure of the material depending on the final product for which it will be used. In order to shift towards a sustainable business model, potential improvements of each step in the natural ornament stone supply chain has to be assessed. Thereby, the waste generated throughout the lifecycle from the extraction of raw material to the disposal of the final product should be analysed (see figure 3.4).

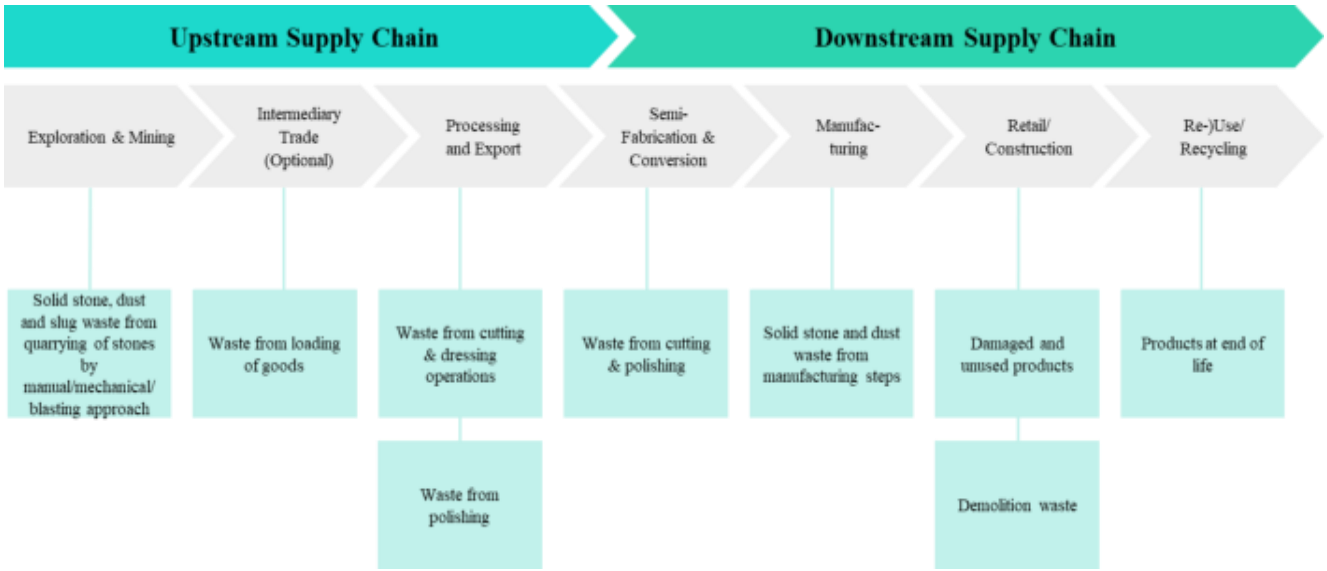

Figure 3.4 - Supply chain in the natural stone industry (See Kickler & Dr. Franken, 2017 and Rana et al.,2016)

Furthermore, water and energy consumption as well as emissions should be considered when developing a sustainable business model for the industry (Kickler & Dr. Franken, 2017).

A sustainable business model for the natural ornament stone industry should meet a variety of sustainability categories: 1) Human & workers' rights, 2) Social welfare, 3) Use of natural resources, 4) emissions & land reclamation and 5) Company governance.

In terms of human & workers' rights, companies should respect human rights and health and safety regulations. These include for example a safe work environment, the compliance with working hours and rest, the prohibition of child labour or safe handling of hazards and machinery. Sustainable businesses should contribute to social welfare including community rights as well as local value added like the payment of taxes, local procurement and the creation of jobs for the local community. When assessing the use of natural resources land use, water use, energy use and material use should be assessed. Mining and quarrying could have a negative impact on the biodiversity and ecosystem. Therefore, legally protected areas, threatened species and ecosystem services should not be disturbed. Furthermore, mining and quarrying operations should be mindful of the local agriculture. The efficient use of water, energy and material is a key element to reduce waste and pollution. Additionally renewable energy and sustainable sourcing should be emphasised. Mine waste and wastewater should be avoided if possible and otherwise disposed responsibly. Special precautions should be taken with regard to hazardous waste. Greenhouse gas emissions, noise and air pollution should be reduced to a minimum. Business and management practices, including business ethics, assessment of environmental and social impacts and regular sustainability reporting ensure a sustainable and long-term achievement of set goals (Kickler & Dr. Franken, 2017).

The efficient use and reuse of material and by-products plays an essential role in the transition towards a circular business model in the ornament stone industry. Through lifecycle assessment of natural ornament stone products, recommendations for action can be derived which can lead companies in the ornament stone industry to a circular business model:

1) Effective exploration and design of the site

   The first step in the mining process is the identification of potential mining areas, either by exploring new natural ornament stone deposits or by expanding existing sites. In the following step, potential deposits are assessed based on geological knowledge, technological and economic feasibility, environmental, socioeconomic and legal regulations and standards, as well as needed investments (European Commission, 2018). The expansion of mineral extraction in Portugal is limited by protected areas (i.e. national parks, water supply infrastructure) and by other land use (i.e. agriculture, urban areas). Furthermore, as in many other countries of the European Union, land-use is restricted mainly by environmental legislations, where mining activities are considered disruptive to the environment and therefore often disregarded in land-use planning (Carvalho et al., 2018).

Mateus et al. (2017) propose a multi-dimensional methodology to assess areas with mineral resources of public importance while addressing the need to 1) ensure the future supply of mineral resources 2) assign specific areas to mineral extraction operations to ensure the mineral development planning. The methodology calculates a score based on the four dimensions: the level of geological knowledge and the economic, environmental and social development acceptance. Multi-scale land-use requires significant communication between stakeholders from land-use planning and the mining sector to decide on the future land-use. Thereby, it should be considered that areas of mineral deposits are limited and mining activities are a temporary operation with the possibility to use the land for other purposes after it, given a responsible and sustainable mining approach (Matheus et al., 2017). Input for the methodology can be provided by information platforms such as the Information System of Portuguese Mineral Occurrence and Resources. The database aims to share knowledge and promote the mineral exploration development (SIORMINP, 2020).

The design of the site can already be an essential step towards an effective mining or quarrying process. A detailed characterisation and classification of the resource and potential waste generation improves the efficiency of the extraction and reduces waste. The choice of the extraction strategy, underground or open-pit technique, influences the design of the site as well as the impact of the procedure on safety and the environment (European Commission, 2019). New tool innovations and state-of the art equipment contribute to an increasing efficiency in quarrying. Non-invasive technologies like Electrical Resistivity Tomography (ERT) and ground Penetrating Radar (GPR) optimize the extraction of mineral resources by precisely determine the extraction area, thus reducing the extraction of by-products and increasing the knowledge about resource characteristics before mining. Moreover, knowledge about the characteristics of extracted waste enable the alignment with legal legislations beforehand and the planning of disposal or re-using methods (European Commission, 2019). In Portugal, various projects have been set up to innovate and develop new technologies. One of them is Inovstone 4.0, a collaborative project between companies and universities with the aim to develop advanced technologies and software for the ornament stone sector (Inovstone, 2020).

2) Effective extraction

The quarrying process of natural stone, for example limestone, produces by-products either in the form of solid waste or in the form of quarry dust, which is particularly generated during the crushing and screening of ornament stones. During the processing of natural stone in plants, dust and small material particles can also mix with water used for the machinery, forming a semi-liquid substance referred to as stone slurry (Galetakis & Soultana, 2016).

Around 58% of material extracted is discarded as waste during the extraction, sawing and cutting process (Rana et al., 2016). Therefore, the optimisation of the extraction, drilling and blasting

process is essential to reduce waste and prevent sterilisation of unextracted mineral material to ensure supply for future generations. Machines, tools and techniques are chosen based on resource characteristics and geological and geotechnical conditions. Detailed knowledge about characteristics and conditions based on simulations in advance enables a targeted extraction, thus increasing energy efficiency and reducing waste generation (European Commission, 2019).

3) Efficient transportation

The infrastructure around the operational side and the selection of the right hauling equipment should be assessed in the design phase. An optimized transportation system to transport materials to processing or deposal sites reduces costs, energy consumption and emissions while increasing productivity (European Commission, 2019).

4) Effective use of extracted materials

The effective exploration of mining areas and extraction of natural ornament stone can minimize the waste generation, but it will not eliminate it. Therefore, methods to use extracted by-products should be assessed. The use of waste could provide economic and environmental benefits for the natural ornament stone sector and extend the lifecycle of primary materials (Galetakis & Soultana, 2016). In general, there are two different ways of dealing with extracted materials that are not used as primary raw materials: filling excavation voids with extracted materials or recover by-products by using them as materials for example in construction (European Commission, 2019).

Depending in the mining method, materials might have to be placed back into the extravation voids. The return of extracted materials into excavation voids helps to avoid or reduce extractive waste. At the same time, the method contributes to site remediation, as the natural ornament stone industry uses its own waste for remediation purposes instead of virgin materials. Furthermore, the method reduces the occupation of land required for the disposal of mineral waste as they do not have to be stored on the surface (European Commission, 2019).

On the other hand, recovered materials can also be reused as raw materials as long as it is technically, economically and environmentally feasible. The utilisation of stone waste depends on the characteristics of the resource as well as the type of waste. Despites the efforts to find effective ways to utilise by-products such as quarry dust, the resource is not yet sufficiently exploited, largely due to legal restrictions. The most common way to use stone waste is in construction. Stone slurry can be used as cement replacement and solid wastes can be added to concrete mixtures. Limestone dust provides great potential for use because it is accessible and in comparison, to marble does not require additional treatment like drying, thus minimizing energy consumption (Galetakis & Soultana, 2016; European Commission, 2019).

In a study by Sivrikaya et al. (2014) the utilisation of natural stone waste dust as stabilisers for clayey soil was analysed. The study proved that stone dust can be used to stabilize and improve soil

that is too soft or expansive, creating the necessary conditions for construction. Other ways to utilize stone waste is as fill materials and concrete aggregates i.e. in asphalt. Moreover, natural stone dust from granite or marble can be added to industrial bricks to improve their composition or be used as sand replacement (Sivrikaya, et al., 2014; Galetakis & Soultana, 2016).

In recent years, the waste generation in Portugal decreased. However, with €1.10 of GDP per kg of materials consumed in 2015, Portugal's resource productivity is lower than the European average. 53% of turnover in the Portuguese manufacturing industry is spent on raw materials while investing 40% of the budget for environmental management in waste management. There is great potential to increase resource efficiency and circularity as well as potential for the innovation of new solutions for waste management. Circular business models should consider an industrial symbiosis between different sectors to exchange and re-use by-products. Industrial symbioses describes the collaboration of companies from different industries to innovate and develop ways to exchange water, energy and by-products as valuable materials for other products. The concept of industrial symbiosis provides the opportunity to re-introduce waste into the productive chain, thus generating additional revenue und potentially creating competitive advantage for all parties involved (BCSD-Business Council for Sustainable Development, 2018).

5) Protection of topsoil and biodiversity

Topsoil is a nutrient rich ecosystem that forms the basis for vegetation. It also filters pollutants from rainwater before releasing it into the groundwater. Topsoil is an important resource that grows over several thousand years, therefore its preservation is particularly important (European Commission, 2019).

Measures to protect the topsoil and biodiversity should be considered in various process steps. During the mapping stage, mechanically cleaning of the mapping traverses might be necessary, thus removing vegetation and topsoil. However, the environmental impact during the mapping stage is marginal and can be limited by replacing topsoil to conceal the extraction void and planting seeds to recover the vegetation. More significant environmental impacts can be observed during the extraction activities, in particular related to excessive land clearance due to road constructions, which can harm the natural vegetation and wildlife. Soil erosions can occur during the exploration stage caused by drilling, material storage or traffic. Furthermore, both soil structure and soil chemistry can be influenced, which can have long-term effects on agricultural viability. The establishment of maintenance workshops can help to avoid the contamination of soil and water.

Moreover, businesses should assess the impact of their activities in biodiversity since exploration activities can lead to a loss of wildlife and disturb their natural behaviours such as breeding (Dimchov & Zoran, 2013).

Businesses that aim to operate more sustainable should pay attention to re-vegetation in order to stabilize topsoil, thus avoiding erosions and re-establishing biodiversity. A feasible and economic way is to reuse the removed topsoil for re-cultivation since it has a high seed content. In some cases, waste rock can be added to a soil mixture to improve the stability (see point 4) (Dimchov & Zoran, 2013).

6) Effective monitoring

Effective monitoring plays an important role in establishing circular economy by verifying that set goals are met and that corrective measures can be taken if needed. It provides reports of the actual state and forms the basis for continuous improvement. In order to establish an effective monitoring system, relevant parameter have to be set such which should promote the reduction of waste, negative effects and hazardous properties (European Commission, 2019).

Circular business models should develop a monitoring framework and define key performance indicators to measure and compare their performance over time. An effective monitoring system also assists in decision making. Businesses should be encouraged to set sustainable objectives and benchmark performance (De Wit et al., 2018).

3.2.5 Integrating industrial ecology thinking into R&D projects in ornament stone industry

The implementation of circular economy in the ornament stone industry will require new business models that will build on collaboration, new ways of consumption and innovative technologies (see chapter 2.4.3). In the European Action Plan, research, innovation and digitalisation are indicated as one of the essential drivers for the transition to a circular economy. Innovation funding such as LIFE or Horizon Europe are set up to promote the development of new products, business models and technologies for production and recycling. Furthermore, the European Institute of Innovation and Technology will support collaborative innovations (European Commission, 2020a).

The global construction market is expected to grow by over 70% until 2025. Therefore, countries that are dominating in the construction industry such as Great Britain are investing in R&D to stay competitive and take advantage of the growth. One of the technologies that are changing the industry as of today is Building Information Modelling (BIM) (HM Government, 2013). BIM is a digital technology that stores large amounts of information and allows to collaborative work on design, construction and operations processes. Thereby it increases transparency throughout all stages of the process, provides real-time information and reduces waste. The technology also has large potential for costs reductions.

Data-driven collaboration in all process steps will enable all partners in the supply chain to fully exploit their capabilities. Real-time management of facilities and networks through remote systems enhance the control of the process. Furthermore, an infrastructure should be set up to control transportation and to strengthen the network capability. Through 3D printing, components could be

created that can be used in smart factory and infrastructure projects. Other innovative technologies such as the Internet of Things, such as smart sensors, could monitor and control operations, track the state of the infrastructure and anticipate necessary maintenance (HM Government, 2015).

In Portugal, the natural stone cluster promotes R&D activities and inter-company and inter-institutional cooperation in order to develop new sustainable ways in the ornament stone industry. To strengthen the leading position of the Portuguese natural ornament stone sector, the natural stone cluster aims to deepen knowledge and increase technical, technological and managerial skills (Cluster Portugal Mineral Resources , 2020). The development and trading of new technologies should increase the competitive advantage of Portugal. Furthermore, the supply chain performance should be improved through customized products, reduced time-to-market and more sustainable operations, thus increasing the image and credibility of Portuguese businesses in the global ornament stone market (Antunes da Silva et al., 2016).

The objectives of the natural stone cluster are further pushed by other projects such as JETSTONE or INOVSTONE that aim to create state-of-the art technologies, concepts and practices. Waste reduction, optimized energy efficiency, increased production flexibility and productivity and the development of new technologies and products are in the focus of the Mobilising Projects (Antunes da Silva et al., 2016).

4 Conceptual framework

4.1 Literature review summary

Today's linear model of consumption and production will not be sustainable in the future. The steady population growth, urbanization and mass industrialization are increasing the demand for resources and are overstraining the naturally regenerative system of the earth (Lehmacher, 2016). With growing wealth and population in the upcoming years, and therefore increasing resource scarcity, our pattern of consumption has to change (Ellen McArthur Foundation, 2013).

Approaches towards a sustainable economy have been widely discussed in literature and were a subject to changes in the last decades. Being first a matter of compliance with legal restrictions, sustainability became important as a strategic approach in the late 1980s and early 1990s. In the early 2000s, sustainability became the focus of management practices and new business models. Different schools of thoughts have developed concepts that aim to create a more sustainable economy by providing alternatives to the current take-make-dispose pattern. In 1989, the concept of circular economy was introduced by Pearce and Turner in 1989.

The circular economy is "an industrial system that is restorative or regenerative by intention and design" (Ellen McArthur Foundation, 2013: 7). The concept aims for restoration, the use of renewable energy, the elimination of waste and the design of new concepts and business models (Ellen McArthur Foundation, 2013).

In recent years, the concept has been widely discussed and influenced businesses as well as governments. Circular business models have been developed that are set to change our ways of sourcing, production, consumption and disposal. Based on a restorative and regenerative design, circular business models aims to reduce waste by prolonging the useful lives of materials and products while keeping their value. Circular business models, however, not only offer opportunities to reuse or remanufacture goods, but focus on a shift of the existing consumption model towards service system and new ways of collaborative working.

In past decades, the demand for raw materials, including wood, fossil fuels, metallic and non-metallic materials, such as natural ornament stone, has steadily increased. The stable supply of raw materials is essential for the European economy with 3.4 million jobs and 206 billion euros of added values related to the industry (European Commission, 2018). Therefore, several governmental actions have been introduced in recent years, such as the Circular Economy European Action Plan which aims to decouple economic growth from resource use. With an expected global growth by over 70% by 2025, the construction market is of significance importance in the transition towards a circular economy.

Portugal is one of the leading exporters of natural ornament stone, dominated by small and medium sized businesses. The extraction and processing of ornament stone poses environmental problems since a large part is discarded as waste. Effective extraction, production and transportation methods have to

be developed to improve the resource efficiency of the industry. Additionally, R&D to create new collaborative business models and innovative technologies such as BIM will be important in the transition to a Circular Economy in the ornament stone industry (Chambel, 2016).

SMEs in the ornament stone industry are becoming increasingly aware of sustainability concerns and the positive impact of operating resource efficient. However, there are both internal as well as external barriers that can hinder the transition to circular business models. Internal barriers can be a lack of awareness know-how, a hesitant organizational culture to change or a lack of cooperation in the value chain. External barriers could be political, environmental, social, technological, legal and environmental factors. Besides barriers there are also enabler that can promote the transition to circular economy, such as the creation of a competitive advantage, the opportunity to expand to new markets and costs savings (Rizos et al., 2016).

4.2 Conceptual framework

Based on the main ideas and concepts of the literature review, a conceptual framework for this thesis was developed. Figure 4.1 represents the conceptual framework. This thesis aims to assess the current level of knowledge of Circular Economy in Portuguese businesses in the ornament stone industry and to analyse the internal and external barriers for the transition.

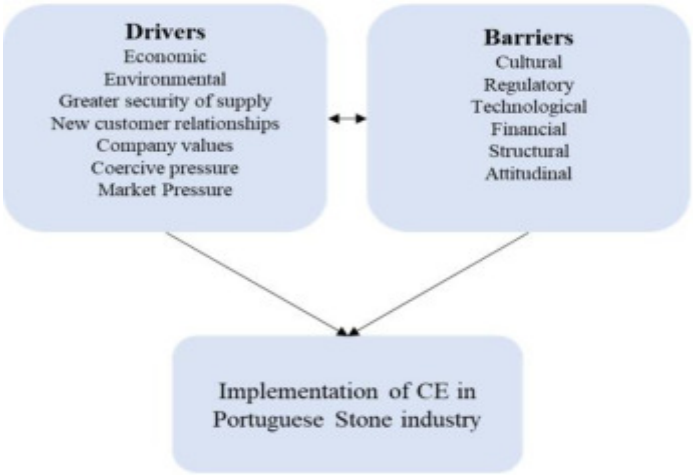

Figure 4.1 - Conceptual framework. Drivers and barriers for the transition to CE

The basis of this framework is the awareness and knowledge of businesses about sustainable concerns and the concept of circular economy. However, even though businesses are becoming increasingly aware of Circular Economy, there are internal and external barriers and drivers that can influence the adaption of this concept (Mont et al., 2017).

Drivers or enablers for this framework will be based on the defined drivers from Mont et al. (2017). Drivers can be differentiated into internal and external drivers. Internal drivers can be economic,

environmental, the benefit of greater security of supply, new customer relationships and company values (see table 4.1).

DRIVERS	
Economic	Cost savings
	Increased resource efficiency
	New revenue streams
Environmental	Avoid risk of hazardous materials
	Improved waste management
Greater security of supply	Build supply chain resilience
	Secure supply of resources
	Reduce price volatility
New and enhanced customer relationships	Customer preferences
	New market segments
	Improved customer relationships
Company values, strategies and aspirations	Stakeholder commitment
	Brand reputation
Coercive pressure	Legal environment
	Customer and organization expectations
Market pressure	Competitors in the market
	Uncertainty of resource supply

Table 4.1 Drivers for the transition to CE

First of all, *economic drivers* for organizations adapting a circular economy approach, could be costs savings. Circular economy business models increase resource efficiency, thus decreases the costs of materials and energy needed (Stahel, 2013). Furthermore, the use of secondary materials could decrease procurement costs and result in a higher margin. New business models such as product-as-a-service or refurbished products could lead to new revenue streams (Mont et al., 2017).

Environmental drivers relate to environmental benefits of circular business models which could be the decreased risk of hazardous materials and improved waste management (Mont et al., 2017) .

Another driver for the transition to a circular economy could be the *improved supply and resilience*. Given the expected increase in consumption of non-metallic materials of 168% by 2050, the security of supply of resources is a major challenge for the upcoming decades. (European Commission, 2018). The adaption of circular Business models could improve the security of supply for businesses and reduce

price volatility (Mont et al., 2017). As a result supply chain resilience will be improved, which better prepares companies to react to disruptions and market changes (Deloitte, 2020).

New and enhanced customer relationships relate to demand-side factors. Customer are getting increasingly aware of environmental issues and sustainability concerns and shift their product preferences accordingly (de Jesus & Mendonca, 2018). Circular solutions could benefit from the preference and attract new markets. Through product as a service companies can intensify their interactions with customers and improve their customer specific offers. Business models built on circular leasing or repurchasing agreements (see chapter 2.4.3) increase the number of consumer touch points and improve customer loyalty (Ellen McArthur Foundation, 2013a).

Company values, strategies and aspirations refers to the commitment of stakeholders to follow a circular approach, thus promoting the adaption of circular business models (Mont et al., 2017). Additionally. Circular business models could strengthen the brands reputation (Ellen McArthur Foundation, 2013a).

External drivers for the transition to Circular Economy business models are coercive pressure and market pressure.

Coercive pressure is based on the isomorphism defined in the sociological institutional theory. Coercive drivers describe the political influence for example through government rules and regulations. Formal and informal pressure from other organizations or from market expectations can influence a business to change. Furthermore, organizations have to comply with the legal environment which could also influence the adaption of circular business models (DiMaggio & Powell, 1983; Mont, et al., 2017).

Market pressure such as strong competition in particular from low-cost countries, shifting customer preferences and the uncertainty of resource supply on the market and the demand for new business models from stakeholders can affect the transition to a circular business model (Mont, et al., 2017).

In addition to the driving forces, there are also barriers that could prevent companies from adapting circular business models. The barriers in the established framework (table 4.2) are cultural, regulatory, technological, structural, financial and attitudinal (Ritzéna & Sandström, 2017; Kirchherr et al., 2018).

Cultural barriers refer to a lack of awareness or unwillingness to shift to circular economy both from the business as well as from the customer side. According to de Jesus and Mendonça (2018) the lack of interest and the insufficient consumer education represents a major barrier. In addition, a hesitant business culture can prevent the change, as circular business models require the integration of the concept into the strategy, mission, vision, goals of the company (de Jesus & Mendonca, 2018).

BARRIERS	
Cultural	Lack of awareness
	Hesitant company culture
	Lack of interest from customers
Regulatory	Missing legal framework
	Low virgin material and energy costs
Technological	New product design and production processes
	Availability of technologies for CE
	High investment costs in technologies and training
Financial	Cost sensibility of SMEs
	High initial investments
	Uncertain revenue and pay-back periods
Structural	Lack of information exchange
	Unclear roles and responsibilities
	Insufficient cooperation with supply chain partners
Attitudinal	Unwilligness to change
	Level of knowledge and understanding of the concept
	Risk aversion

Table 4.2 Barriers for the transition to CE

Regulatory barriers can be represented in the lack of an appropriate legal policies, which could not only hinder the transition but also reinforce the existing linear system (de Jesus & Mendonca, 2018). Low energy costs as a result of state subsidies could further undermine the implementation of CE (Kirchherr et al., 2018).

Technological barriers can occur since circular business models also often require the integration of new technologies for new product design and production processes. The lack of available technologies on the market and the related R&D costs for technology innovations as well as the lack of knowledge can be a major barrier especially for SMEs (de Jesus & Mendonça, 2018; Rizos et al., 2016).

The uncertainty of generated revenue through innovative offers such as product-as-a-service models and needed investments to integrate the change in all departments of a company can represent a *financial barrier* (Ritzéna & Sandström, 2017). Higher cost sensitivity and insufficient financial means are a burden especially for SMEs. Smaller businesses are also more dependent on a pay-back period of their investments. Additionally, indirect costs for time and training of staff can be a barrier (Rizos et al., 2015).

Structural barriers for moving towards circular economy can be a lack of information exchange and incapability to cooperate with supply chain partners. Cooperation is essential since one organisation in the value chain will not be able to close the cycle alone (Jonker et al., 2018). Unclear responsibilities in the process can cause additionally problems (Ritzéna & Sandström, 2017).

Attitudinal barriers refers to the willingness it change and the attitude of decision-makers towards the circular economy concept. This can be influenced by a low level of knowledge and understanding of the concept, which can prevent the shift to a circular business model. Moreover, risk aversion of a company can hinder the transition (Ritzéna & Sandström, 2017).

5 Methodology

The literature review compared the concept definitions and analysed existing business models.

The geographical focus of the research will be Portugal. Furthermore, the focus will be small and medium sized companies. In Europe, where the majority of companies are small and medium enterprises, it is especially important to include SMEs into the research on CE. Therefore, this thesis aims to assess the level of knowledge on circular business models in SMEs in Portugal and analyse their opinion and problems with the concept.

Since CE is a model that can only bring advantages - despite the complicated transition – it is necessary to come into contact with several organizations in order to understand the extent to which there is knowledge, willingness or initiative to initiate circular business models. The research was conducted using a theoretical framework based on the scientific literature, which was supplemented with primary data collection using structured questionnaires and interviews carried out on a sample of Portuguese companies belonging to the ornament stone industry sector. After the collection and processing of data, the results of the study are expected to bring explanation for the research questions already presented:

RQ1 What is the level of knowledge of the circular economy in Portuguese ornament stone industry sector?

RQ2 What are the key challenges and enablers for SMEs in the ornament stone industry in the transition towards circular economy?

5.1 Research design

The current state of interest and potential approaches to implement a circular model should be analysed. Thereby, the focus were SMEs in Portugal that operate in the ornament stone sector.

Qualitative interviews (Appendix A) with experts from companies operating in the ornament stone industry were be conducted to select primary data. The theoretical framework developed in chapter 4.2 was supplemented with the selected primary data. Personal interviews with experts help to get a deeper understanding of the current knowledge of CE in Portuguese SMEs in the ornament stone industry. A qualitative research framework is chosen to focus on the collection of detailed information about how SMEs understand the concept of CE, what their opinion about the concept is and their potential adhesion to CE. Personal interviews allow follow up questions and personal reaction to the interviewees' reaction and opinion.

5.2 Data collection

Secondary data was collected through a literature review using current books, research papers and documents of EU regulations as a main source. Since circular business models is a topic that has been discussed in recent years, literature from the past years were expected to be especially valuable.

Primary data was collected through interviews with business experts, working in SMEs in the ornament stone industry. The collection of primary data was essential for the work, since it is important to assess the current level of knowledge of SMEs on circular business models. Because circular business models only generate value when they are applicated, the primary data would give valuable insight into the opinion, knowledge and adhesion of SMEs in Portugal. The data collection was qualitative, consisting of open-ended questions in the interviews. This form of data collection was chosen to get a deep understanding of the opinion of business experts on the topic and to capture their thoughts, ideas and potential problems on adopting a circular business model.

5.3 Data analysis

Since the data collection was qualitative, there were e no pre-determined responses. Therefore, the data analysis consisted of the following steps:

1) Data preparation
2) Research Objective
3) Developing Framework
4) Identifying patterns and connections

After conducting the interviews, it was necessary to get familiar with the data and start basic observations for patterns. This step also required the transcription of the interviews. In the next step, the data had to be analysed in the light of the research objective and the questions that can be answered with the data collected. Moreover, a framework was developed to order the data according to their responses. In the last step, patterns and common responses that can answer the research question were identified.

6 Results analysis and discussion

6.1 Level of knowledge and extend of engagement

The first part of the interview was aimed at assessing the level of knowledge of the concept Circular Economy and the level of engagement. A lack of awareness represents a major cultural barrier that could prevent companies from adapting Circular Economy (de Jesus & Mendonca, 2018).

All interviewees had at least a general understanding of the concept. However, the practices were not always referred to the term Circular Economy, but rather to *"sustainability"* or *"environmental cycle"* (interviewee Nr.1, interviewee Nr. 2).

According to Jesus & Mendonca (2018) circular economy concepts have to be embedded into the corporate culture to successfully undergo the shift. Thus, the representation of Circular Economy in the company's strategy, mission and vison is essential. All interviewees put emphasis on the integration of Circular Economy into the company's values as one of the interviewee quotes *"We have been practicing this idea for a long time now. It has been part of our culture."* (interviewee Nr.2).

The majority of interviewees were also aware of the proposal of the European Commission to promote the Circular Economy. *"We are committed to the European Green Deal for a clean and circular economy [...] and we have already some projects with this objective.*" (interviewee Nr.4). Only one interviewee was not aware of the European Commission proposal. Furthermore, three of the interviewee's companies were certified under the ISO 9001 and ISO 14001, an environmental management system to operate environmental responsible (ISO, 2015). These companies are not only willing to engage in the concept, but are also following standardized quality parameters to ensure sustainable processes in their business.

Moreover, all respondents agreed that there is a strong interest from their SME or cluster to engage further with the concept. The concept was given high importance for the development of the sector. *"We think that this type of concept is not only the future but should be the present in every company."* (interviewee Nr.2).

The largest knowledge gap was identified in the area of circular business models. One interviewee did not have knowledge about circular business models while two were still in the process of gathering more information about it. Only one respondent stated knowledge about circular business models. "*The outmost respect for the environment, from the conscientious stone extraction to the safe delivery of every stone piece, nothing goes to waste and it is a continuous resource-efficient renewable cycle."* (interviewee Nr. 2). However, the lack of knowledge about circular business models might also be a lack of awareness since all of the interviewed companies engage in the concept already.

Circular Economy principles are used in all companies or clusters of the respondents. All interviewees stated that the adoption of Circular Economy principles improved their business. The main

factor mentioned was the added value by re-using by-products that would otherwise be discarded as waste. Additionally, the product portfolio could be increased as a result. Other key factors mentioned were an improved use of fuels, and a better suppliers' evaluation. Furthermore mentioned were the responsible quarry exploration and the improvement of the environment in general.

6.2 Drivers

The existing literature has already analysed drivers that can support the adoption of Circular Economy principles (see chapter 4.2).

In this study, economic drivers represent, among environmental drivers, one of the key motivators for the implementation of the concept. For circular business models to be successful, they must offer economic value such as cost savings or additional revenue streams (Stahel, 2013; Mont et al., 2017). In particular the re-use of by-products and thus the reduction of waste were mentioned as the main economic factors. Waste management plays an essential role in the ornament stone industry. Instead of dumping by-products from extraction and production as waste, they find a valuable use in other forms, e.g. as gravel. "*Our recycling system is organized to allow the complete reuse of stone, letting what once was considered waste for our company to be reborn as a raw material to other industries."* (interviewee Nr. 2).

Likewise, the reuse of water used in the processing of ornament stone is an important factor in the ornament stone industry. A cyclonic re-use of the water in the factory as well as alternative water sources (i.e. rainfall water) reduce the need of clean drinking water, resulting in economic as well as environmental benefits.

Furthermore, more efficient and less expensive processes as well as a more efficient use of energy are expected following circular economy principles. Moreover, long-term benefits could be obtained since *"the companies that are involved in the Circular Economy will be stronger [...] in the future."* (interviewee Nr.3).

Environmental drivers are the second key driver mentioned by all interviewees. Both, environmental and economic drivers are often interrelated since the former may also result in economic benefits. The main focus expressed in this study was the preservation of the environment by reducing the impact of professional activities. This includes responsible quarry exploration as well as the preservation of the landscape where exploration and production processes take place. Similarly, machines are installed that reduce the impact of ornament stone processing on the environment, both by reducing waste as well as through the use of renewable energy. All interviewees expressed a sense of responsibility to work sustainable in the ornament stone industry as one quotes *"our main goal as a natural stone manufacturer is to give back what nature give us."* (interviewee Nr.2).

The responsibility to operate sustainable is also represented in the corporate strategy of the respective companies. Commitment of stakeholders and the adaptation of circular economy principles in a company's values, strategies and aspirations is a driver towards the circular economy (Mont et al., 2017). Employees are being involved and educated on the matter. *"We have employee days where we for example plant trees with the family of our employees. We also teach children from a young age about these principles."* (interviewee Nr.5).

Appreciation of the principles of the circular economy is expected not only from the company itself, but from the entire network. Suppliers and other partners in the supply chain must commit to the concept, e.g. through responsible sourcing and fair working conditions.

Pressure from customers or the possibility to enter new markets can encourage companies to shift to circular economy (de Jesus & Mendonca, 2018). In this study, the opportunity to expand the product portfolio and offer new high-value products were identified as the main drivers on the demand side. Moreover, an increasing shift of customer preferences towards sustainable operating companies was reported.

Another driver identified in this study is coercive pressure. Coercive pressure refers to the political influence such as government rules and regulations (DiMaggio & Powell, 1983; Mont et al., 2017). Companies are adapting circular economy principles to comply with national and international policies. Furthermore, the importance of involving clusters in the decision-making process of regulations for the ornament stone industry was expressed.

In general, the importance of clusters in the ornament stone industry was highlighted by all interviewees. Clusters actively promote R&D activities to develop new processes and products that allow maximum circularity in the sector. In particular, the opportunities for collaboration and knowledge exchange with universities and partners in the network were seen as a chance for further development of the concept for the ornament stone industry. The collaborative work in a cluster will help *"to introduce the concept in SMEs and to create a real Circular Economy in the Mineral Resources."* (interviewee Nr.4).

6.3 Barriers

Besides drivers the study also identified barriers that can prevent organisations from shifting towards Circular Economy. It is important to understand the obstacles faced by SMEs in the sector in order to support their transformation with the right approaches. In this study, attitudinal, financial and structural barriers represent the biggest barriers.

Essentially, a company must have the willingness and the necessary knowledge to be able to implement circular economy principles. A lack of knowledge and understanding of the concept as well as a risk aversion of decision-makers represent an attitudinal barrier (Ritzéna & Sandström, 2017). The

knowledge and skills to support this transition are not yet available in every organisation. Furthermore, the urge to change is not understood by everyone as one interviewee stated: *"The main barrier is perhaps to understand that we don´t have another planet and that it is urgent to start living with an Economic Circularity view."* (interviewee Nr 4). The expectation of a long training period for employees and years of improvement were presented as another obstacle, especially for smaller companies. Even if the necessary knowledge is available in an organisation, the willingness to share information is required to operate in a circular economy within the organisation's network. A lack of trust and the risk of sharing intellectual property represents a barrier in the transition towards circular economy.

Furthermore, smaller companies face a lack of financial resources and usually rely more on a shorter pay-back period of investments (Rizos et al., 2015). High initial investments and a longer adaptation time were identified as one of the biggest hurdles for SMEs. Many companies lack the required funds to adapt their services to circular economy principles and as a result continue to operate in the existing linear model. The high level of competition in the industry may also prevent companies from taking the risk of a long adjustment period as one interviewee quotes: *"In order to stay competitive things sometimes have to happen fast and companies do not have the time to implement the principles."* (interviewee Nr.5). Moreover, decision-makers do not always understand the value proposition of a circular business model and are therefore not willing to invest into it. Additionally, there is still the need to develop viable solutions for many areas, i.e. sustainable energy.

Regulatory barriers are the third key obstacle identified in this study. Insufficient support from governments and a lack of public incentives are preventing businesses to shift to a circular economy model. It was stated that regulations should encourage the transition through positive incentives as well as punishment in case of failure to comply to the policies.

As minor barriers, the lack of integrating circular economy principles into the strategy, mission and vision of the company was mentioned. Furthermore, the amount of by-products in particular in the marble industry might be challenging.

Technological barriers can occur since circular business models also often require the integration of new technologies for new product design and production processes. The lack of available technologies on the market and the related R&D costs for technology innovations as well as the lack of knowledge can be a major barrier especially for SMEs (de Jesus & Mendonça, 2018; Rizos, et al., 2016).

The uncertainty of generated revenue through innovative offers and needed investments to integrate the change in all departments of a company can represent a *financial barrier* (Ritzéna & Sandström, 2017). Higher cost sensitivity and insufficient financial means are a burden especially for SMEs. Smaller businesses are also more dependent on a pay-back period of their investments. Additionally, indirect costs for time and training of staff can be a barrier (Rizos et al., 2015).

Structural barriers for moving towards Circular Economy can be a lack of information exchange and incapability to cooperate with supply chain partners. Cooperation is essential since one organisation in the value chain will not be able to close the cycle alone (Jonker at al., 2018). Unclear responsibilities in the process can cause additionally problems (Ritzéna & Sandström, 2017).

7 Conclusions

7.1 Final conclusions

The literature review showed that the concept of circular economy is gaining importance and provides a valuable alternative to the linear system. The increasing scarcity of natural resources such as ornament stone will further increase the pressure to develop a new generation of technologies, business models and methods to ensure a sustainable operating model. With an expected steadily growth in the next years, the construction industry is central to the transition to a circular economy. The ornament stone industry faces challenges to develop sustainable extraction and processing methods as well as transportation modes that preserve the natural environment. As one of the largest global exporters in the ornament stone industry, Portugal is a leading force in the development of circularity in the ornament stone sector.

While adapting a circular business model promises economic benefits, there are still barriers that companies have to overcome to transform their supply chain. With most businesses in Europe being small and medium-sized enterprises, it is important that activities promoting the circular economy particularly target these companies. Governmental regulations such as the European Action Plan as well as industry clusters play an important role in the promotion of the concept and the innovation of new technologies and organizational approaches.

Knowledge about the concept is a key factor for a successful transformation towards a circular economy. Therefore, the study presented in this work, aimed to assess the current level of knowledge of Circular Economy in SMEs in the Portuguese ornament stone industry, as well as addressing the current obstacles and drivers that companies face in the transition. Through the literature review and the collection of primary data through interviews the following research questions were answered:

- RQ1 What is the level of knowledge of the circular economy in Portuguese ornament stone industry sector?
- RQ2 What are the key challenges and enablers for SMEs in the ornament stone industry in the transition towards circular economy?

SMEs in the ornament stone industry are becoming increasingly aware of sustainability concerns and the positive impact of operating resource efficient. However, there are both internal as well as external barriers that can hinder the transition to circular business models. Internal barriers can be a lack of awareness know-how, a hesitant organizational culture to change or a lack of cooperation in the value chain. External barriers could be political, environmental, social, technological, legal and environmental

factors. Besides barriers there are also enabler that can promote the transition to circular economy, such as the creation of a competitive advantage, the opportunity to expand to new markets and costs savings (Rizos et al., 2016).

This thesis showed that economic drivers both through cost savings as well as the creation of additional revenue streams represent a major motivator for SMEs to adapt a circular economy business model. Moreover, environmental aspects such as the reduction of harmful impacts on the landscape are main objectives for companies. However, the collected data also showed obstacles that SMEs face in the transition to a circular economy business model. Small businesses are particularly affected by a lack of knowledge. So, special focus should be placed on helpful sources of information for SMEs. Also, small businesses often to not have sufficient financial means to support the transition. It is therefore advisable to further develop financial support and incentives that specifically address the needs of small businesses in the future.

7.2 Work limitations and future work

This thesis investigated the level of knowledge in SMEs in the ornament stone industry in Portugal as well as the drivers and barriers these companies are facing. Since Circular Economy is still a topic under development, the subjects offers many areas for future work.

With growing importance and integration of the subject into governmental regulations, an increase of studies on the impact of introduced actions are to be expected. As this work focused on SMEs in the ornament stone industry, further research in other sectors could be beneficial to assess the different challenges that companies face in terms of their business environment.

In addition, a broader perspective could be taken in terms of geographical focus. Rapidly growing economies such as Asia will have an increasing impact on resource consumption and environmental aspects. An assessment of approaches and government programmes for companies in this geographical area could therefore be interesting with regard to the global transition to a circular economy.

As mentioned in this work, research and development and new technologies play an important role in the advancement of the circular economy. A next step to this work could therefore be a detailed analysis of already existing innovations as well as potential for further development. Furthermore, the point of view from consumers could be investigated since consumer behaviour could highly influence the willingness of companies to switch to a circular economy business model. Both incentives as well as barriers for consumers to use products and services from businesses that adapted a circular model could be assessed.

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Appendix

Appendix A

The interviews should give answers to the questions:

1. What is your current understanding of the circular economy and the extent to which you wish to engage in it?
2. Are you aware about the recent European Commission proposals that seek to promote the circular economy?
3. Do you/ your SME show interest in the concept of the circular economy?
4. Do you/ your SME have knowledge about circular business models and if yes to which extend?
5. Do you use circular economy principles for your business?
   If yes, do you think it has improved/negatively impacted your business?
   If yes, how it has improved/negatively impacted your business/production/revenue?
6. Do you measure how circular you/ your SME are? If yes, how?
7. What are barriers in the implementation? Which are the primary obstacles/barriers for companies in order to readjust and become circular today?
8. What are the external barriers and enablers SMEs could experience on a political, economic, social, technological, legal and environmental level (PESTLE) to readjust and become circular?
9. What are motivators and enablers in the implementation? Which are the motivators and enablers from the SMEs perspective to readjust and become circular?)
10. Do you expect the SMEs to experience any further barriers/enablers in the future?
11. To what extend can SMEs influence those?
12. Can you identify any interrelations between those barriers and enablers? Do they influence each other?
13. The circular economy necessarily requires greater information sharing (e.g. a company that designs a product must share more openly what is in it and how it can be dismantled). Should SMEs be concerned about this from an intellectual property point of view?
14. Belonging to a cluster gives many advantages through increased competitiveness because of a common pool of resources, innovations, research, and development (R&D) and other common cluster activities. Which importance does the topic Circular Economy have for cluster managers and other regional actors in stone industry?