CIRCULAR ECONOMY SOLUTIONS AND THEIR ECONOMIC IMPACTS IN CONSTRUCTION COMPANIES OPERATING IN FINLAND

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ABSTRACT

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Circular Economy (CE) is a systemic approach to economic development designed to tackle global challenges such as climate change and biodiversity loss by decoupling economic growth from environmental pressure. Despite its growing popularity, the implementation of CE in the construction industry is still in its infancy stage. In securing an environmentally, socially, and economically sustainable future, the implementation of CE in the construction industry plays a crucial role. The environmental impacts of CE implementation have been quite broadly studied because they are the key aspects that distinguish it from the linear model. However, for the CE to emerge as the new standard economic model, it must also provide economic growth along with environmental sustainability. Hence, the main objective of this thesis is to explore the economic impacts of CE implementation in construction companies operating in Finland. To understand the economic impacts, it is necessary to know from what kind of CE practices they arise. Therefore, the secondary objective is to identify what CE practices construction companies have implemented in their operations in Finland. Finally, this thesis also sheds light on measurement practices associated with the economic impacts of implemented CE practices. The topics are explored by conducting a qualitative study based on seven semi-structured interviews within seven different construction companies that operate in Finland.

The research findings show that CE practices implemented during the construction phase are often associated with waste management, cooperation and research, and sustainable procurement. The economic impacts of CE implementation are mainly perceived as positive, especially in the long-term, by the companies that participated in the study. The positive economic impacts are primarily associated with increased business opportunities, cost savings from waste management, and material and energy efficiency. In contrast, costs were mainly associated with investments in research and development, high costs of recycled materials, and costs concerning the training of employees. Very few measurement practices to monitor the success of CE implementation and economic impacts related to it are currently in use. However, there is clearly interest in them in the field.

Keywords
circular economy, construction, CE implementation, economic impacts, waste management

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TIIVISTELMÄ

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Kiertotalous on kokonaisvaltainen lähestymistapa talouskehitykseen. Se pyrkii vastaamaan globaaleihin haasteisiin, kuten ilmastonmuutokseen ja luonnon monimuotoisuuden köyhtymiseen irti kytkemällä ympäristöpaineet talouskasvusta. Kasvavasta suosiosta huolimatta kiertotalouden käyttöönotto rakennusalalla on vasta alussa. Kokonaisvaltaisesti kestävän tulevaisuuden varmistamiseksi kiertotalouden mukaisten käytäntöjen jalkauttaminen rakennusalalle on avainasemassa. Kiertotalouden ympäristövaikutuksia on tutkittu melko laajasti, koska ne ovat avaintekijöitä sen ja lineaarisen talousmallin välillä. Jotta kiertotalous voisi korvata lineaarisen mallin tulee sen olla myös taloudellisesti kannattavampi vaihtoehto. Tästä syystä tämän opinnäytetyön päätavoitteena on selvittää kiertotalouden käyttöönottoon liittyviä taloudellisia vaikutuksia Suomessa toimivissa rakennusyrityksissä. Taloudellisten vaikutusten ymmärtämiseksi on tiedettävä, millaisista kiertotalousratkaisuista ne johtuvat. Tästä syystä opinnäytetyön toisena tavoitteena on tunnistaa, mitä kiertotalousratkaisuja rakennusalan yritykset ovat ottaneet Suomessa käyttöön. Lisäksi tässä opinnäytetyössä tarkastellaan toteutettujen kiertotalousratkaisuiden taloudellisiin vaikutuksiin liittyviä mittauskäytäntöjä. Aiheisiin etsitään vastauksia kvalitatiivisen tutkimusmenetelmän kautta, joka perustuu seitsemään puolistrukturoituun haastatteluun seitsemästä eri Suomessa toimivasta rakennusalan yrityksestä.

Tämän tutkimuksen tulokset osoittavat, että rakennusvaiheen kiertotalousratkaisut liittyvät pääosin jätehuoltoon, kestävään hankintaan, sekä yhteistyöhön ja tutkimukseen. Kiertotalousratkaisujen taloudelliset vaikutukset koettiin tutkimukseen osallistuneiden rakennusyritysten toimesta pääosin myönteisinä, etenkin pitkällä aikavälillä. Taloudelliset hyödyt liittyvät pääasiassa lisääntyneisiin liiketoimintamahdollisuuksiin, jätehuollon kustannussäästöihin sekä materiaali- ja energiatehokkuuteen, kun taas kustannukset liittyivät pääasiassa tutkimus- ja kehitysinvestointeihin, kierrätysmateriaalien korkeisiin kustannuksiin ja henkilöstön koulutuskustannuksiin. Toistaiseksi käytössä on hyvin vähän mittauskäytäntöjä liittyen kiertotalousratkaisuiden käyttöönoton onnistumiseen ja niiden taloudellisten vaikutusten seuraamiseen, mutta kiinnostusta niitä kohtaan on selvästi.

Asiasanat
kiertotalous, rakennusala, kiertotalousratkaisut, taloudelliset vaikutukset, jätehuolto

Säilytyspaikka
Jyväskylän yliopiston kirjasto

CONTENTS

LIST OF TABLES AND FIGURES

TABLES

FIGURES

LIST OF ABBREVIATIONS

CE – Circular Business
CBM – Circular business model
CDW – Construction and demolition waste
DfD – Design for Disassembly
EC – European Commission
EU – European Union

1 INTRODUCTION

1.1 Background

Our current economic arrangement, where we take, make and dispose, lacks the capability to meet the current, let alone the future needs of mankind (Furkan, 2017). We only have one planet earth, but currently, we use as many ecological resources as if we lived on 1.6 earths (Global Footprint Network, 2020). If we continue with our unsustainable consumption patterns, we will end up with a depletion of natural resources and a shrinking of the earth's carrying capacity (Magdoff, 2013). To prevent this from happening and to meet the future needs of mankind, the concept of Circular Economy (CE) has received growing attention worldwide (Ghisellini et al., 2016). Ghisellini et al. (2018) define the Circular Economy as an economic system in which resource inputs, creation of waste, emissions, and energy leakage are minimized by slowing and closing material and energy loops. To achieve the aim of creating a regenerative closed-loop system, CE employs methods such as reuse, repair, refurbishing, remanufacturing, and recycling. At its core, CE strives to simulate nature, which does not discard matter at the end of use in its biological cycle but instead uses it as a productive input in another natural process (Górecki et al., 2019). Although the CE concept's scientific and research content is still largely superficial and unorganized, it has been proven that the concept is a viable, sustainable, and unavoidable alternative to the current linear economy (Furkan, 2017; Korhonen et al., 2018).

The construction industry still mainly uses the traditional linear economic model, which hinders an environmentally sustainable future (Benachio et al., 2020). Building construction and operations are in a significant role in climate change mitigation and more sustainable use of natural resources. The buildings and construction sector accounts for 36 percent of final energy use and 39 percent of energy-related carbon dioxide emissions on a global scale (International Energy Agency, 2019). The construction sector alone consumes 32 percent of the world's natural resources and generates 25 percent of solid waste globally (Yeheyis et al., 2013). The industry is, in addition, met with the expectation that the global middle class will grow by approximately 150 million people per year (Kharas, 2017). Consequently, to provide well-being and adequate quality of life for people in the near future, we must build the same urban capacity in the next 40 years that was built in the last 4000 years (Eberhardt et al., 2019).

In Finland, building construction and operations are in a major role on a societal scale. According to Finnish Association of Civil Engineers (2019), the industry accounts for 15 percent of our national GDP and employs 20 percent of the workforce. Besides economic and social importance, the industry's environmental impacts are enormous and largely in line with global percentages. When the mining industry is left out of the equation, the construction industry is responsible for half of the waste generated in Finland (Statistics Finland, 2020). According to the Finnish innovation fund Sitra (2019), around 10 to 15 percent of materials used in the construction industry end up as waste already during the construction phase. That alone indicates a huge potential for adopting CE practices in the industry.

The implementation of the CE approach in the construction industry is crucial in securing an environmentally, socially, and economically sustainable future. According to Green Building Council Finland (FIGBC, 2018), CE in the built environment means assimilated procedures within the industry and policies that support those procedures that steer the industry towards sustainability. CE needs to be considered in the whole value chain of the industry, and current practices and business models must be challenged by new innovations (FIGBC, 2018). Comprehensive studies must be conducted about multiple issues such as system approach, aspects and indicators, methodological issues, and frameworks in order to effectively implement CE in the construction industry (Hossain et al., 2020). Discussion about CE has focused mainly on its environmental impacts since those are the key elements distinguishing it from the linear model. Nevertheless, to replace linear economy, CE must also become an economically preferable option (Ranta et al., 2018). Therefore, while also exploring CE practices that construction companies operating in Finland have implemented into their operation, the main focus of this thesis is on the economic impacts of implemented CE practices. Furthermore, several recently published papers about CE in the construction industry point out that evaluation of circularity performances and CE measurement are among the topics that are not well understood yet (e.g. Benachio et al., 2020; Hossain et al., 2020). For that reason, this Master's Thesis additionally aims to expand the current understanding of measuring CE and provide new knowledge for the construction companies to help them in the transition toward the CE.

1.2 The aim and the structure of the study

The initial idea for the subject of this Master's Thesis evolved from an observation that economic impacts of CE implementation are not as widely recognized as environmental impacts. In fact, there is a lack of understanding regarding how implementing CE into a company's operations generates value and revenue in a business context (Ranta et al., 2018). As a result of this, companies that do not consider environmental values as important as economic values tend to be less willing to implement CE into their operations. Also, even if environmental sustainability is part of company's values, practical steps to execute solutions that are in line with this value are less likely to actualize because of the uncertainty of the economic impacts of these actions. If the economic impacts of CE implementation were more visible and better articulated for these kinds of companies, they could be more willing to implement CE.

Various factors, such as global and national policies and regulations, are already guiding the construction industry towards circular economy and its implementation. However, the implementation of CE practices is left for companies themselves, and the current status of CE implementation within the industry is, that it is lagging behind many other industries (Adams et al., 2017). This thesis explores different CE practices that construction companies operating in Finland have implemented into their operations and perceived economic impacts of those practices. The aim is to expand the knowledge regarding economic impacts of CE implementation and possible economic drivers that contribute to CE implementation.

The main research question of this thesis is:

What kind of economic impacts implemented CE practices have in construction companies operating in Finland?

The sub-questions are:

1. What kind of CE practices construction companies operating in Finland have implemented into their operations?

2. How are the economic impacts of implemented CE practices and targets related to them measured in construction companies operating in Finland?

Implementation of CE can generally be divided into three different scales: micro level, meso level, and macro level. Since this Master's Thesis focuses on CE implementation by individual construction companies, the main focus is on the micro level. When considering the entire lifecycle of a building, construction companies are typically associated with the construction phase, which means that most of the CE practices addressed in this thesis are related to the construction phase in one way or another (Adams et al., 2017). However, to effectively implement CE into a company, actions are required, not only by the company itself but also by other operators within its supply chain network. Therefore, CE implementation on the meso level is also considered in this thesis from a construction company's point of view when exchanging resources within a supply chain network.

This Master's Thesis is divided into six sections. Section 2 forms the theoretical framework of this thesis and introduces the reader to existing CE-related literature and other aspects and key concepts related to the subject of the thesis. Section 3 discusses the research methodology used in this thesis and explains the decision-making process behind methodological choices as well as the data gathering process. Section 4 presents the research findings derived from the empirical research phase. Section 5 discusses research findings by reflecting on the literature review. Finally, Section 6 summarizes the research findings, discusses the trustworthiness and limitations related to the thesis, and provides suggestions for future research.

2 THEORETICAL FRAMEWORK

This section provides the theoretical framework of this thesis. In order to provide a comprehensive framework for the subject of this Master's Thesis, the section starts by addressing key concepts in the big picture and proceeds towards more detailed issues related to the topic after the reader has been provided with general knowledge regarding the concept of CE. The first chapter addresses the CE concept first from a general perspective and then in relation to the construction industry. The second chapter discusses CE implementation by construction companies that operate in Finland. Finally, the third chapter focuses on the economic impacts of implemented CE practices and measurement practices associated with them in construction companies operating in Finland.

2.1 Concept of Circular Economy

This chapter, which is divided into two subchapters, will provide the reader with a comprehensive understanding of the CE concept. In the first subchapter, the concept of CE is discussed from a general perspective without associating it with any specific industry. The background and the definition of the concept are explained, and opportunities related to it are discussed. The second subchapter focuses on the CE in the construction industry specifically. The current state of the CE within the industry will be discussed, as well as its future. At the beginning of the second subchapter, the concept within the industry is discussed on a global scale, but the focus moves on to a national scale towards the end of the chapter.

2.1.1 Circular Economy in general

The adverse effects of linear take-make-dispose -economy are endangering economic stability and integrity of natural ecosystems, which are essential for the survival of humanity (Ghisellini et al., 2016). CE is a systemic approach to economic development designed to benefit businesses, society, and the environment and to replace the current unsustainable linear economy (Ellen MacArthur Foundation [EMF], 2015a). The CE concept cannot be traced back to a single date or author in history, but its roots are in concepts developed in the late 1970s (EMF, 2013b). Significant concepts that have affected the current CE concept include regenerative design, performance economy, and the cradle-to-cradle approach (EMF, 2013b). CE-related literature is often associated with so-called 3R's, or as Ghisellini et al. (2016) put them: the founding principles of CE. 3R's refer to reduction, reuse, and recycling. Barreiro-Gen & Lozano (2020) refers to 4R's, which are reduction, repairing, remanufacturing, and recycling, instead of 3R's, when describing different levels of recovery. Potting et al. (2017, p.5) uses 9R framework in their book to describe different circularity strategies within a production chain. Those 9R's, in order of priority, are refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and recover. There are various combinations of different R's in CE literature. According to research by Kirchherr et al. (2017), a combination of recycling, reuse and reduction is the most commonly used in scientific literature. All the R's mentioned above can be linked to different circularity strategies that ultimately aim to reduce our consumption of natural resources and minimize the amount of waste we produce.

Only during the past couple of decades, the concept of CE has started to gain broader interest among scholars, businesses, and politics (Lacy & Rutqvist, 2015; Leising et al., 2018). The CE concept has gained increasing popularity in recent years, particularly because of Ellen MacArthur Foundation's work on promoting it and its opportunities through several reports and other publications (Benachio et al., 2020; Geissdoerfer et al., 2017). EMF characterizes CE as an economy that is *"restorative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles"* (EMF, 2015b, p. 2). The literature review paper by Benachio et al. (2020) found that EMF's definition for CE was the most cited description of the concept among recent scientific publications that focused on CE in the construction industry. Several scholars have reviewed different definitions for the concept and concluded that definitions from EMF's reports are most cited among scientific papers (e.g., Benachio et al., 2020; Geissdoerfer et al., 2017; Kirchherr et al., 2017). However, Kirchherr et al. (2017, p. 224) analyzed 114 different CE definitions and proposed their own definition of the concept based on it: *"… an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers."* Nonetheless, this definition is based on the coding framework, which was created by analyzing 114 existing definitions, so rather than seeing it as a definitive CE definition, it can be seen as a summary of the core principles and aims of the concept. Kirchherr et al. (2017) also found that an abundance of different definitions for the concept has caused confusion among researchers, which has led to misleading results in their research. Based on the findings mentioned above and the aim of this Master's Thesis, EMF's definition for the concept is applied in this Master's Thesis. Few industry-specific definitions for the concept are mentioned later in this thesis, but those do not apply to the concept from a universal point of view.

Earlier research on CE considered it mainly as an approach to more appropriate waste management (Ghisellini et al., 2016). However, this kind of narrow view of CE fails to demonstrate the magnitude of the concept because recycling, reuse, or recovery options are not always suitable in every context, although they work in some situations. Moreover, some waste conversion technologies that are based on biotechnology and green chemistry can sometimes be economically and environmentally more unsustainable than the conventional technology addressed, which further calls for prevention more than treatment (Ghisellini et al., 2016). Instead of seeing CE as a more appropriate way to manage waste, it must be considered in the bigger picture. According to Ghisellini et al. (2016), this means that instead of just regenerating materials and energy from waste, transformational new solutions that address the entire life cycle of any process and consider the interaction between the process and the environment and the economy in which it is embedded should be designed. When the CE concept is considered this way, it has the potential to not only regenerate resources but also generate entirely new ways of doing things and help society to increase wellbeing and sustainability at minimal material, energy, and environmental costs (Ghisellini et al., 2016).

According to EMF (n.d.), CE is based on three basic principles: design out waste and pollution, keep products and materials in use, and regenerate natural systems. By designing out waste and pollution we can avoid the negative impacts of the economy, such as GHG emissions, structural waste, and water pollution, that harm our planet. Around 80 percent of all negative environmental impacts are determined already at the design stage of production (EMF, n.d.). In order to change this, the whole lifecycle of materials and products that we design and create must be considered, and waste and pollution need to be seen as design flaws rather than a natural part of the lifecycle. The second principle, keeping products and materials in use, is an essential part of closing the loop. Products made of technical materials should be designed in a way that they are reusable and durable. Depending on their purpose, they should also be easy to repair or remanufacture. Organic materials, on the other hand, move in a biological cycle and regenerate through biological processes. As the last principle of CE, regenerating natural systems means not only protecting the environment but improving it by returning valuable nutrients to ecosystems (EMF, n.d.).

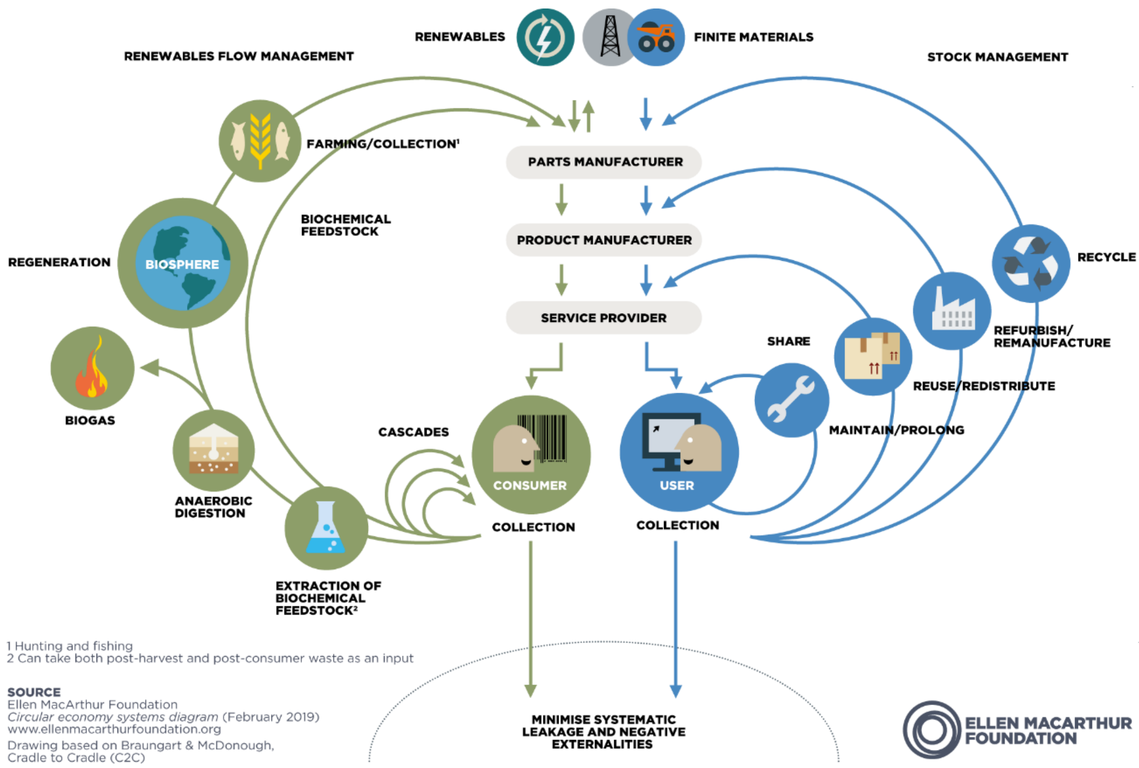

Figure 1. Circular economy systems diagram. Copyright © Ellen MacArthur Foundation [n.d.].

In recent years, companies have started to notice the opportunities that the CE offers for their business. Besides drawing wider interest towards the CE concept, EMF has been in an important role especially in engaging the business community (Bocken et al., 2017). EMF's Circular Economy System Diagram (Figure 1), or as it is commonly known, the "butterfly diagram" has been momentous in visualizing the essence of CE and a hierarchy of circularity strategies (EMF, n.d.). The diagram demonstrates the continuous flow of technical and biological materials, whilst adding an element of financial value. Instead of one loop, biological and technical cycles are separated into two distinct halves in the systems diagram. Biological materials move on the left side of the diagram in green cycles. After the materials are consumed, they can re-enter the natural world by biodegrading, and nutrients embedded into them return to the environment (EMF, n.d.). Technical materials, that are represented on the right side of the diagram in blue, cannot re-enter the environment like biological materials. These materials, in order to create a closed loop, must cycle through the system so that their value can be captured and recaptured over and over again (EMF, n.d.).

Economic growth has traditionally been linked to virgin resource inputs, meaning that in a linear take-make-dispose -economy, profits increase, and the economy grows when more natural resources are extracted (EMF, n.d.). CE makes it possible to gradually decouple economic growth from use of virgin raw materials. According to Ghisellini et al. (2016), decoupling environmental pressure from economic growth is no less than the utmost goal of the whole concept.

Interest in CE has gained traction also among policymakers, influencing national governments such as China and intergovernmental agencies like European Union (Geissdoerfer et al., 2017). China started to recognize a mismatch between its rapid economic development and resulting negative environmental impacts at the beginning of the 2000s, and in 2009 a law called "Circular Economy Promotion Law of the People's Republic of China" took effect (Lieder & Rashid, 2016). Since then, an increasing number of scientific papers related to CE has been published in China. CE has gained increasing popularity also in Europe since European Commission (EC) established its first agenda to transform the EU economy into a circular one in 2015 (Geissdoerfer et al., 2017). As a part of the European Green Deal and the European Union's aim to become climate neutral by 2050, European Commission has created a Circular Economy Action Plan (European Commission, 2020b). The plan makes a decisive contribution to the EU's goal of becoming a resource-efficient, climate-neutral and competitive economy. The Circular Economy Action Plan is in an important role in ensuring the EU's long-term competitiveness by decoupling economic growth from resource use. According to a study, making the circular economy a policy priority would increase the EU's GDP by 0.5 percent by 2030 (European Commission, 2018). In addition to economic growth and reduced negative environmental impacts, prioritizing CE policy would also lead to around 700,000 net increase in jobs in the EU.

Sitra (2016) published the world's first national road map to a CE that aims to make Finland a global pioneer in CE by 2025. The road map was created in close collaboration with government ministries and several representatives from the public and private sectors. It presents concrete projects and effective CE measures and solutions to accelerate the transition to a more circular economy (Sitra, 2016). In addition to environmental goals, the aim is to increase the economic competitiveness and well-being of the country and its residents. In April 2021, the Finnish Government adopted a resolution on promoting a circular economy (Ministry of the Environment [YM], 2021). The resolution is based on a vision that the Finnish economy will be based entirely on a carbon-neutral circular economy by 2035, which means a complete transition away from the linear economic model. The resolution sets concrete targets for the consumption of nonrenewable natural resources, and also restricts the use of renewable natural resources. Concrete objectives and indicators, specified required measures and allocated resources pave the way toward greater circularity and systemic change (YM, 2021).

2.1.2 Circular Economy in the construction industry

This chapter provides knowledge of the construction industry's current state regarding CE and sheds light on industry-specific challenges and opportunities. Environmental, economic, and social problems are caused by the linear economic model, which is still largely used within the construction industry. The linear take-make-dispose -economy within the industry is characterized by phases of building's life cycle, which starts from the extraction of virgin raw materials, that are then processed into construction materials (Mangialardo and Micelli, 2018). These materials or elements are assembled on-site during the construction phase, often in a way that they cannot be disassembled later. In the end of life of the building the construction materials become obsolete and are disposed as waste along with all the other waste that is generated during the process (Mangialardo and Micelli, 2018).

Within the industry, the research on the application of CE principles has been relatively slow and limited compared to industries that produce short- and medium-lived consumer products (Adams et al., 2017). Several industry-specific reasons, such as the uniqueness of construction projects, large supply chains, and the industry's inability to implement innovation fast, have hindered the adaptation of the CE concept (Benachio et al., 2020). During the 2000s, research regarding CE in the built environment focused strongly on end-of-pipe solutions to manage waste generation, which led to improvements in managing demolition waste (Adams et al., 2017). Even though various research has been conducted on this topic, the development of knowledge and tools is still needed to adopt CE in practice on a larger scale within the industry (Lacy & Rutqvist, 2015). Over the last decade, research on implementing CE in the industry has started to become more common. Benachio et al. (2020) conducted a systematic literature review of peer-reviewed articles about Circular Economy in the construction industry and found 45 articles published during the last five years that are strongly related to CE in the construction industry. The paper also found that the number of CE-related publications in the built environment has grown exponentially since 2017, which indicates that it is currently a widely researched topic. A literature review paper by Hossain et al. (2020) concurs with the findings of Benachio et al. (2020) and highlights the significant increase of scientific contributions in the field in recent years due to emerging recognition of environmental impacts and resource efficiency in the construction industry.

As the construction industry significantly stands out from various other types of industries, various researchers have suggested industry-specific definitions for CE. Leising et al. (2018, p. 977) define the CE approach in the construction industry as *"A lifecycle approach that optimizes the buildings' useful lifetime, integrating the end-of-life phase in the design and uses new ownership models where materials are only temporarily stored in the building that acts as a material bank"*. The definition by Leising et al. (2018) is more explanatory and extensive than the definition by Pomponi & Moncaster (2017, p. 711): *"building that is designed, planned, built, operated, maintained, and deconstructed in a manner consistent with CE principles"*, which solely lists different phases of building's life cycle and combines them with the CE term relying entirely on readers understanding about CE principles. The definition by Leising et al. (2018) also requires understanding of specific terms, but it also distinguishes considerably from general CE definitions and provides an additional industry-specific input in contrast to them.

The construction industry plays a vital role in transitioning from the linear economic model to CE. Throughout the entire life cycle of a building, several activities under processes cause adverse environmental impacts (Hazem & Breesam, 2019). Built environments contribute to problems such as resource depletion, pollution, and climate change. The construction sector is one of the largest emitters of GHG emissions and users of primary energy (YM, 2019). When the full lifecycle of a building is considered, half of all extracted virgin raw materials can be attributed to the sector globally (European Commission, 2020a). According to a report by Sitra (2018), the majority of discussions in the past regarding buildings' CO_2 emissions have focused on the use phase of its life cycle. This is understandable because traditionally, the use phase causes most of building's CO_2 emissions. However, as buildings get more energy-efficient and a larger portion of energy comes from renewable sources, the importance of the construction phase increases substantially (Sitra, 2018). As this Master's Thesis focuses on CE implementation by construction companies operating in Finland and the economic impacts associated mainly with their operations, the main focus is on the construction phase.

As a resource-intensive sector, the construction sector also possesses a significant potential to induce a positive impact in pursuing sustainability-related goals, such as resource efficiency, circular material flows, and net-zero emissions (YM, 2019). The built environment is more and more involved in the production of renewable energy and will play an important role in the energy systems of the future (FIGBC, 2018). A paradigm shift within the industry from linear economy to CE is seen as inevitable to ensure sustainable use of natural resources in the future (Hossain et al., 2020). This means that we must rethink the way we design, produce and utilize. Sustainable construction practices can generate several benefits, e.g., less construction waste and environmental emissions, lower energy and water consumption, material conservation, lower construction cost, shorter construction time, improved quality of buildings, higher competitiveness, new business models to enable value creation and enhanced occupational health and safety (Adams et al., 2017; Hazem & Breesam, 2019). According to a report by EMF (2015c), the economic saving potential by applying CE in the European built environment is over 340 billion euros by 2030 through the use of primary resources and energy.

CE offers various opportunities in the construction industry, and the European Commission has chosen the built environment as one of its key targets in its policy for CE (European Commission, 2020a). Although interest in CE among policymakers and businesses in the field is increasing and the research on CE in the construction industry has grown exponentially in recent years, its effective implementation in the industry is still in its infancy stage (Hossain et al., 2020). National and supranational policies are paving the way toward CE implementation, but the concrete steps to implement CE practices are left to companies themselves (Prieto-Sandoval et al., 2018). Industry-specific reasons, such as complex supply chains and the industry's inability to adapt quickly to changes, have hindered the implementation of CE practices (Benachio et al., 2020). As mentioned earlier, scientific research has mainly focused on waste management and recycling in the past instead of considering the whole life cycle of buildings and other products (Adams et al., 2017; Hossain et al., 2020). In other words, research has focused more on treatment rather than prevention. Benachio et al. (2020) identified several research gaps from the field, one of which is the development of CE business models within the construction industry. According to Hossain et al. (2020), to effectively implement CE in the construction industry, more profound knowledge is required of the system approach, frameworks, methodological issues and aspects. In addition, Hossain et al. (2020) emphasize that CE measurement and evaluation of circularity performances are not yet entirely studied. In a literature review study of 155 articles on CE by Ghisellini et al. (2016), only a few research papers discuss or focus on CE indicators and measurement, which further calls for additional research on the topic.

2.2 Implementation of Circular Economy in a construction company

This chapter provides knowledge on how CE can be implemented into a construction company's operations and what kind of barriers and opportunities its implementation bears. The chapter is divided into three subchapters. While this Master's Thesis focuses on exploring economic impacts of CE, it is also necessary to understand other objectives of the concept and its implementation to provide comprehension on how CE can generate economic value for a company (Ranta et al., 2018). In the first subchapter, different scales of implementation are introduced, and implementation and aspects related to it are discussed from an industry-wide perspective as well as from the perspective of a single construction company. Different kinds of CE practices are introduced in the second and third subchapters.

2.2.1 Scales and requirements of implementation

CE generally operates in three different scales, that are micro level, meso level and macro level. Ghisellini et al. (2016) reviewed 155 articles on CE and divided them according to the different subjects and categories converging to CE. A fair number of reviewed articles discuss CE principles and CE models, yet most of them focus on implementation of different CE concepts in various case studies across three main scales. Micro level focuses on CE implementation in a single company or by a single individual, whereas macro level consists of CE implementations in local, regional and national levels. Meso level falls in between these two, and CE implementation at this level refer to development of industrial symbiosis networks, eco-industrial parks and other similar productive networks (Ghisellini et al., 2016). An industry, in this case construction industry, which consists of several lines of business, such as, civil engineering, material manufacturing and building construction is also considered as meso level (Adams et al., 2017; CE Center, 2018).

Barreiro-Gen & Lozano (2020) emphasized that most of research papers have focused on CE implementation at macro and meso levels, whereas research regarding micro level implementation has been more limited. CE implementation at micro level, or in other words, by a single organization, usually refers to improvement of organization's environmental performance, for example, by reducing consumption of resources, minimizing waste or designing more environmentally friendly products (Barreiro-Gen & Lozano, 2020). Since this Master's Thesis discusses economic impacts and indicators related to CE implementation in Finnish construction companies, the main focus is consequently at micro level. However, to effectively implement CE principles to a single company within an industry, actions are required, not only by the company itself, but also by its stakeholders at meso level (Bilal et al., 2020). Few macro level factors are also discussed to provide deeper understanding about the environment in which Finnish construction companies operate. Górecki et al. (2019) and Adams et al. (2017) observed that implementation at macro level and meso level is necessary to effectively implement CE at micro level.

To implement CE in a company, new ways of working and a new way of organizing are necessary (Parida & Wincent, 2019). There is no one universal approach on how to implement CE on an organizational level because the implementation is highly dependent, for example, on what kind of products or services the organization provides (Barreiro-Gen & Lozano, 2020). For several industries there already exists an encompassing framework which introduces effective standard practices to implement CE into company's operations within that certain industry (Adams et al., 2017). However, within construction industry there is still a lack of these kind of known standard practices for CE implementation according to several authors (Adams et al., 2017; Benachio et al., 2020). Although, various factors indicate that the progress and implementation of CE principles in the construction industry is quick (Hossain et al., 2020). Adams et al. (2017) highlighted that there is an industrywide awareness of the CE concept but besides the lack of implementation framework, stakeholders, such as, subcontractors, designers and clients are still quite unaware of the whole concept, which causes a key challenge for the implementation.

To effectively implement CE during the construction phase, several aspects across all three different scales require attention. Changes in business models, construction methods and legal regulations are required to effectively implement CE in the construction industry (Górecki et al., 2019). Legal regulations that affect CE implementation in Finnish construction companies are forced mainly at the macro-economic level by the EU and the Finnish government. As mentioned in previous sections, these public authorities are actively forcing new policies that aim to replace linear economy with CE, which paves the way for CE implementation at all three scales of implementation. In conclusion, one can say that the legal environment in which construction companies operate in Finland is steadily transforming more favourable for companies that have implemented CE solutions into their business. Changes in business models and construction methods are more in the hands of a single company than changes in legal environment. However, even though changes in business models and construction methods can be executed at micro level to some extent, to effectively implement CE, cooperation with stakeholders at meso level is necessary. Along with new business model, Ghisellini et al. (2018) emphasized the importance of integrated supply chain and extended responsibilities of different actors within the supply chain of a building. Hossain et al. (2020) identified the supply chain of materials as a key step towards successful implementation of CE. Adams et al. (2017) grouped different CE aspects derived from CE literature according to different stages across building's life cycle. Waste minimization, off-site construction and procuring reused and recycled materials were seen as the key aspects in CE implementation during construction phase. These aspects overlap with business models and construction methods observed by Górecki et al. (2019). Changes to them can partially be implemented unassisted but as several authors highlighted and Barreiro-Gen & Lozano (2020, p. 3493) aptly concluded: *"organisations are not islands but have to collaborate with their stakeholders in order to achieve the goals of CE and sustainability"*.

2.2.2 Circular business models and cooperation

A business model is a set of company's strategic decisions that define how it captures or creates value through its internal activities and relationships with its stakeholders (Urbinati et al., 2017). In a quest to a more circular business model (CBM), a company might have to reformulate the ways it creates value for its customers, how its processes and activities are employed to provide the promised value and how it generates financial income (Parida and Wincent, 2019). The most fundamental part of transitioning to a more circular business model is to replace the traditional linear flow of "resource-product-waste" with a circular flow of "resource-product-waste-renewable resource".

Urbinati et al. (2017) developed a framework on how companies can implement CE into their business by either adapting circularity into their existing business model or by creating a completely new business model. The framework is based on a taxonomy proposed by the authors that distinguish CE business models between two major dimensions. The first dimension is customer value proposition and interface, which focuses entirely on implementation at the micro level. This dimension defines the CE implementation as "proposing value to customers". Urbinati et al. (2017) identified three main modifications of applying it: (1.) shifting from pay-per-own to pay-per-use approach, (2.) higher degree of cooperation between a company and its customers, and (3.) payment for use- or result-oriented services instead of payment for ownership. From a construction company's point of view application of this dimension is dependent on who is their customer. A construction company often acts as a contractor who executes the building, while a separate client orders the construction and possibly facilitates its operation and maintenance during the use phase. In this typical case, the client is the construction company's customer, which means that the customer value proposition dimension cannot be directly implemented. However, the client sets sustainability requirements for the contractor, which means that the construction company must comply with the required standards. In some cases, the construction company facilitates the building's operation during the use phase and, therefore, sells or rents the apartments directly to consumers. In that case, the construction company can apply the three above-mentioned modifications of proposing value to customers.

The second dimension is the value network, which focuses on implementation at both micro level and meso level. This dimension defines *"the ways through which interacting with suppliers and reorganizing the own internal activities"* (Urbinati et al., 2017). In practice, this means managing activities of reverse supply chain and cooperating more with participants involved within the supply chain. Reverse supply chain, or its broader concept, reverse logistics, is especially important in closing the loop when exchanging construction materials. Reverse logistics enables the manufacturer (and the contractor) to receive new material inputs from the tail end of the supply chain in a form of recovered materials with recovered value (Górecki et al., 2019). This, however, means that to be able to recover materials from the building at the end of its lifecycle, construction structures must be designed in a way that they are easily obtained later (Górecki et al., 2019). This practice is described as design for disassembly, which is further explained in subchapter 2.3.2 (Eberhardt et al., 2019). For a company that is accustomed to typical activities of the forward supply chain, adopting activities of the reverse supply chain usually requires new professional ability from the management and new technological equipment (Urbinati et al., 2017).

Winkler (2011) discusses implementing CE into a company's production system by cooperating with different operators within its supply chain; this can be associated with the value network dimension by Urbinati et al. (2017). Winkler (2011) highlights the importance of cooperation between companies involved in the supply chain, even when operating at the micro level. Especially in the construction industry, where supply chains are typically large, understanding the production processes also at the meso level is necessary to achieve a more effective circular pattern (Pomponi and Moncaster, 2017; Wrinkler, 2011). When implementing CE solutions to a company's production system, some planning and decision making can be done at the meso level, whereas some are carried out within the company at the micro level (Winkler, 2011). At the meso level, the companies must set joint environmental goals, indicators, and measurement principles for cooperation. Appropriate indicators and metrics that are derived from common goals must be set at an organizational level. In this kind of supply chain network, individual strategies and decisions of single operators are influenced by common goals and strategies (Winkler, 2011). The benefits of such cooperation for a single company can be vast in comparison to only implementing

CE at the micro level. According to Winkler (2011), possible benefits include increased competitiveness and profitability, improved environmental and economic performance and increased company value. Parida and Wincent (2019) also point out that through a business model that accounts for extended cooperation with stakeholders, a company can induce greater opportunities for the distribution of risks, shared accountability, and improved service delivery.

Ghisellini et al. (2016) imply that CE implementation at the meso level only refers to production systems; hence it must be considered only when exchanging resources such as materials, energy and byproducts within the supply chain network. However, the focus of their study was on industrial symbiosis, which traditionally addresses resource exchange between separate entities. Cooperating with partners and forming interorganizational networks can also be beneficial not only when exchanging resources, but also when exchanging knowledge and combining skills from various companies (Parida and Wincent, 2019). Those can be used, for example, in overcoming complex sustainability-related challenges. Nevertheless, circularity of resources is such a crucial part of CE implementation in the construction industry that CE in the built environment cannot be achieved without efficient circularity of materials (Sitra, 2019). According to a study by Zeng et al. (2018), there is an apparent positive correlation between construction supply chain integration and sustainable use of construction materials. As various research suggests, almost any interaction between companies that aims at greater sustainability is beneficial for a single company.

Furthermore, the framework developed by Urbinati et al. (2017) for CE implementation is not industry-specific but instead views implementation from a quite general point of view. According to Eberhardt et al. (2019), the construction industry differs from other industries in its complexity in a way that general CE implementation frameworks cannot be directly applied to it. Within the construction industry, several aspects of CE implementation require further research, especially in a whole-systems context but, on the other hand, various research shed light on CE implementation during a particular phase of building's lifecycle (Adams et al., 2017). After all, even though there are various research gaps regarding CE implementation at an industry-wide scale, this Master's Thesis focuses particularly on implementation during the construction phase.

Several industry-specific barriers hamper the implementation of CBMs in the construction industry. These are most notably associated with the value network. Building projects traditionally require inputs from a great number of stakeholders within a complex supply chain (Adams et al., 2017; Eberhardt et al., 2019). Economic costs and environmental impacts occur at every stage of the chain, making it essential to cooperate with everybody within the supply chain. However, getting every stakeholder to engage is much easier said than done. System thinking and understanding that every stage of the chain is an integral part of the whole is necessary for every stakeholder. Varying goals and conceptions of different stakeholders across the supply chain can easily lead to insufficient cooperation because benefits of implementing CE practices may not be shared equally to everyone across the supply chain, and even if they were, stakeholders tend to focus on short-term goals and benefits instead of long-term ones, such as sustainability (Eberhardt et al., 2019). In addition, initiatives related to environmental sustainability are often seen in a negative light, for instance, as additional work because potential economic profits are not always visible to the stakeholders.

Lack of cooperation between short-sighted stakeholders in a complex supply chain is a huge challenge but can be overcome with the right kind of communication and economic incentives. According to Eberhardt et al. (2019), economic incentives for CE are necessary in order to get individual stakeholders engaged in pursuing CE as a common goal within the industry. Therefore, a better conception of economic benefits when implementing CE for each stakeholder is required. Long-term investments together with cooperation between different actors within the supply chain, can lead to greater benefits than acting alone for individual gains (Eberhardt et al., 2019).

2.2.3 Construction process and waste management

Construction requires large amounts of materials and energy. Traditionally buildings are constructed in a way that when they come to the end of their life cycle, they are decommissioned by demolition, producing a great amount of waste (Eberhardt et al., 2019). As earlier research on CE in the construction industry has primarily focused on waste management, significant quantities of materials are recycled at the end of buildings' life cycle and during the construction phase at present (Eberhardt et al., 2019). Unfortunately, these recycled materials lose part of their value in the process, or in other words, are downcycled. Vast amounts of materials also still end up as waste. Consequently, only an insignificant amount of the building materials' inherent economic value is exploited (Pomponi and Moncaster, 2017). Although waste management has been a constitutive part of CE-related literature for quite a long time and recycling of construction materials has significantly improved in Finland in recent years, there is still plenty of potential for improvement. High standard waste management is a crucial part of CE (YM, 2018).

Waste minimization is strongly interconnected to the founding principles of CE or 3R's, as the purpose of those R's is to minimize the amount of waste produced. Waste minimization is a term that is often used in the literature to describe a set of practices that aim to reduce the amount of waste produced. Adams et al. (2017) identified waste minimization as one of the critical aspects in CE implementation during the construction phase. Construction and demolition waste (CDW) has also been recognized as one of the key areas of focus in Finland's national waste plan (YM, 2018). The national waste plan aims to reduce the volume of CDW and raise its material recovery rate to 70 percent. In terms of waste generation during the life cycle of a building, the end-of-life phase is the most impactful as it accounts for around 50 percent of waste generated during the building's life cycle (Benachio et al., 2020). However, sometimes up to 80 percent of most environmental, social, and economic cost factors are determined already during the planning and design phase of a building project (Winkler, 2011). Therefore, the design phase is crucial when it comes to ensuring resource efficiency. The construction phase falls in between the design phase and the end-of-life phase, which means that it does not directly affect either of them. Consequently, to impact these stages of a building's life cycle, the construction company must aim for extensive cooperation within its value chain to achieve its sustainability-related goals. According to Sitra (2019), 10 to 15 percent of construction materials end up as waste during the construction phase, and that is where construction companies can have a significant direct impact. Government Decree on Waste 179/2012, section 16 states that the holder of CDW must organize a separate collection for at least the following waste types: concrete, brick, mineral tile and ceramic waste; gypsum-based waste; non-impregnated wood waste; metal waste; glass waste; plastic waste; paper and cardboard waste; soil and waste rock material.

Waste management follows the order of priority, which is commonly known as the waste hierarchy (Figure 2). The waste hierarchy is often demonstrated in the form of an inverted pyramid, in which the option higher up is favoured in comparison to options below it. The most sustainable option is to prevent waste production in the first place. Not ordering more construction materials than needed is a simple example of this on a construction site. The second most favourable option is to prepare waste for reuse. Densley Tingley et al. (2017) divided the reuse of structural construction materials into reuse on the same site and relocated reuse for the whole building, component systems, and building elements. The third option after reducing and reusing is recycling. Recycling means material recovery, in which waste material is reprocessed into new products, materials, or other substances that serve either original or some other purpose. At present, most building elements are designed and manufactured so that reusing is impossible, and recycling is the most sustainable option available. Therefore, separated waste collection is particularly important in ensuring that waste materials are being somehow exploited. If waste cannot be recycled, it should be used for energy recovery or utilized in some other way (Kuittinen, 2019). An example of other utilization methods than incineration for energy is using, e.g., concrete and brick waste as backfill material. Waste disposal is the last resort of the waste hierarchy. The only exception for following the waste hierarchy is if some other option is environmentally more sustainable than the other one (Kuittinen, 2019). For example, emissions from transportation to a faraway recycling plant can cause more significant harm than incineration for energy in a local waste treatment plant. In Finland, section 8 of the Waste Act 646/2011 obligates construction companies to comply with the waste hierarchy (order of priority).

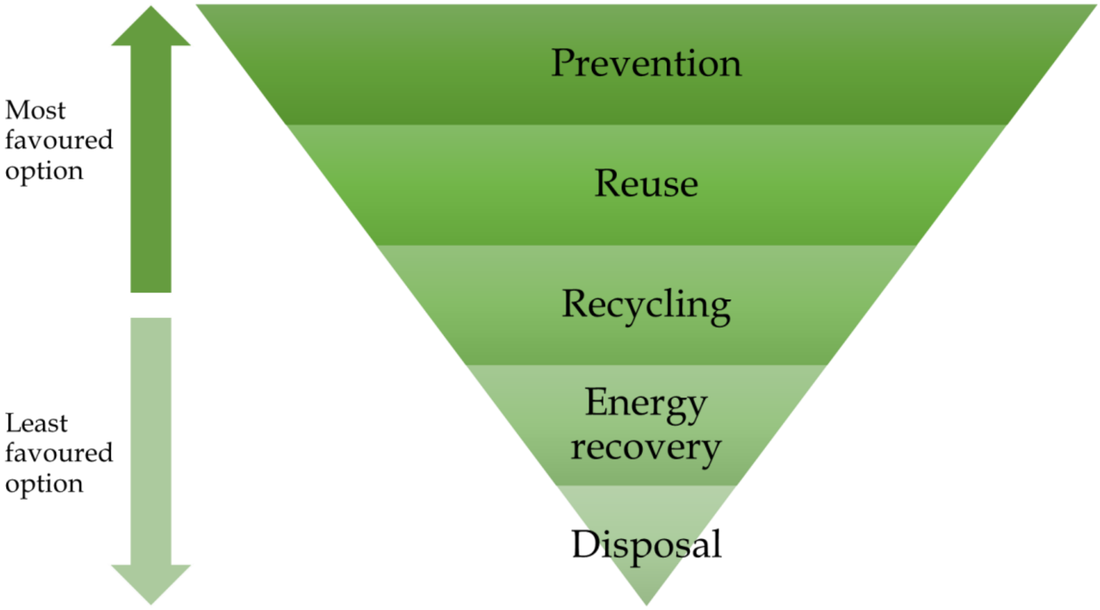

Figure 2. Waste hierarchy. Adapted from Kuittinen, (2019).

Increasing circularity will eventually shift the focus away from improving downstream processes such as waste collection and recycling to upstream processes of production and consumption (Bocken et al., 2017). According to Eberhardt et al. (2019), a high degree of reuse material recoverability is the most effective CE practice from an economic and environmental point of view. A high degree of reusability is achieved, for example, by means of design for disassembly (DfD). However, efficient utilization of reuse practices, such as DfD, requires significant changes in building methods and waste management (Eberhardt et al., 2019). Additionally, to achieve holistic circularity of materials within the industry, aspects such as high durability of materials, use of prefabricated building elements, standards to ensure the quality of reusable materials, and development of recovery schemes are important and should be thoroughly considered (Hossain et al., 2020). This kind of transition also requires extensive cooperation within the supply chain network and changes in the practices of all actors throughout the whole supply chain (Bocken et al., 2017; Eberhardt et al., 2019).

2.3 Economic impacts of Circular Economy implementation

Economic sustainability is an essential part of CE, but literature covering economic impacts of CE often addresses it together with environmental (and social) impacts, which makes it challenging to discuss the economic aspect separately. The economic aspect has already been mentioned above in various contexts, albeit the environmental aspect has been the main subject of discussion. This chapter aims to bring forth the economic aspect more distinctly and leave the environmental aspect in the background. The chapter is divided into two sub-chapters. The first sub-chapter addresses the history and the current state of the economic system and the importance of the economic impacts of CE in contrast to its environmental impacts. The second sub-chapter explores the direct economic impacts of CE implementation and addresses the lack of prior research on measuring of economic impacts of CE implementation.

2.3.1 Focus towards the economic impacts

During the past few centuries, excessive and incremental industrialization has consumed large quantities of natural resources and generated considerable amounts of waste. On the other hand, it has changed the world for the better in many ways, such as goods and services have become accessible to people at cheaper rates, the quality of life of an average person has increased, and the economy has grown significantly. In other words, besides having only adverse effects, the traditional linear economy has benefitted humankind in various ways, especially from the economic point of view. Traditional business models that use the take-make-dispose -model have been the most economically beneficial option available for a long time and still often continue to be, especially in the short-term. The downside of the traditional economic model is that it completely ignores the environmental damage it causes in the long-term (Prieto-Sandoval et al., 2018). However, these drawbacks are still often not tangible for a single company, for which reason a business model that follows the principles of the linear economy is still a viable option for many companies.

Understanding of the environment's limits led to an increase in the real prices of natural resources at the turn of the millennium after a century's worth of real price declines (EMF, 2013a). Even though prices have partially reversed since the first decade of the 21st century, the quick upwards surge of prices worked as a wake-up call for economists and businesses to realize the volatility of resource prices. Consequently, companies have started to notice that the linear approach increases their exposure to risks, particularly higher resource prices (EMF, 2013a). Moreover, companies' risks associated with natural resources are not limited only to their prices but also to their supply. Mangialardo and Micelli (2018) stated that the price and availability of natural resources, materials, and commodities manufactured from them would be increasingly costly and scarce in the future.

The traditional economic model has worked well for the benefit of humankind in the past, but it has all happened at the expense of the environment. Discussion about CE usually focuses on its environmental benefits because those are the key aspects that distinguish it from the linear model. However, for the CE to emerge as the new standard economic model, it must provide economic growth along with environmental sustainability (Ranta et al., 2018). Hence, while gradually decoupling economic growth from resource use, CE must simultaneously be able to compete with the linear model economically. Lacy and Rutqvist (2015) have contributed to literature related to this subject by coming up with the term 'circular advantage', which means competitive advantage gained by a company that embraces CE. Circular business models are crucial in determining the economic impacts of implementing CE practices in a company. Scientific studies about CE from a business model perspective have primarily focused on a sustainable business model approach, in which environmental, societal, and economic values are combined (Ranta et al., 2018). However, according to Ranta et al. (2018), research that focuses solely on the economic impacts of CE implementation is still limited. Scientific papers that address the economic impacts of CE in the construction industry seem to consider them always together with environmental impacts (Ghisellini et al., 2018). Moreover, no existing research paper was found that addresses these impacts solely from the perspective of a construction company during the construction phase. For these reasons, most of the papers cited in the next two sub-chapters either address the subject from a non-industry-specific point of view or discuss it from the perspective of the whole life cycle of a building.

2.3.2 Economic impacts in a construction company

As concluded earlier, CE fundamentally strives to simulate nature, which does not discard matter at the end of use in its biological cycle but instead uses it as a productive input in another natural process (Górecki et al., 2019). Implementation of this paradigm in the construction industry enables the construction process to be conducted cost-effectively because waste materials can be recovered and used as new resources, reducing the demand for virgin raw materials. All different circularity strategies ultimately aim to reduce the consumption of natural resources and minimize the amount of waste produced. According to EMF's report (2015a) that covers CE from a generic, non-industry-specific perspective, CE-related activities offer businesses two types of direct economic benefits: cost savings from materials or components and increased revenues. Cost savings from materials occur, for example, due to parts recovery or when procuring secondary raw materials instead of virgin raw materials (assuming that they are cheaper). Additional sales and higher unit prices can generate higher revenues.

At present, parts recovery primarily happens through waste management. As the research regarding CE within the construction industry has largely focused on waste management in the past, its economic impacts are also better understood than the economic impacts of other aspects of CE. As a general principle, environmental and economic values go hand in hand in the waste hierarchy. This means that when building materials or components are, for example, reused as a whole, they maintain their inherent economic value better than when the same materials are being either recycled or used for energy recovery (Eberhardt et al., 2019). In a similar manner, it is preferable from an environmental perspective to reuse instead of recycling or use for energy recovery because reuse requires lesser energy consumption. In a multiple-case analysis by Ranta et al. (2018), which focused on multiple industries, recycling was recognized as the main source of economic value in each of the four companies included in the study. Value was generated either by selling recycled materials, which created new streams of revenue or by selling products that were partly made from recycled materials, yielding savings in material costs. As addressed before, also in the construction industry, significant quantities of materials are recycled during the construction phase at present (Eberhardt et al., 2019). This, however, means that materials' inherent economic value is not efficiently exploited. Figure 3 shows how increased circularity affects economic and environmental value generation. The highest economic and environmental benefits can be achieved by reusing entire buildings instead of building elements, components, or modules.

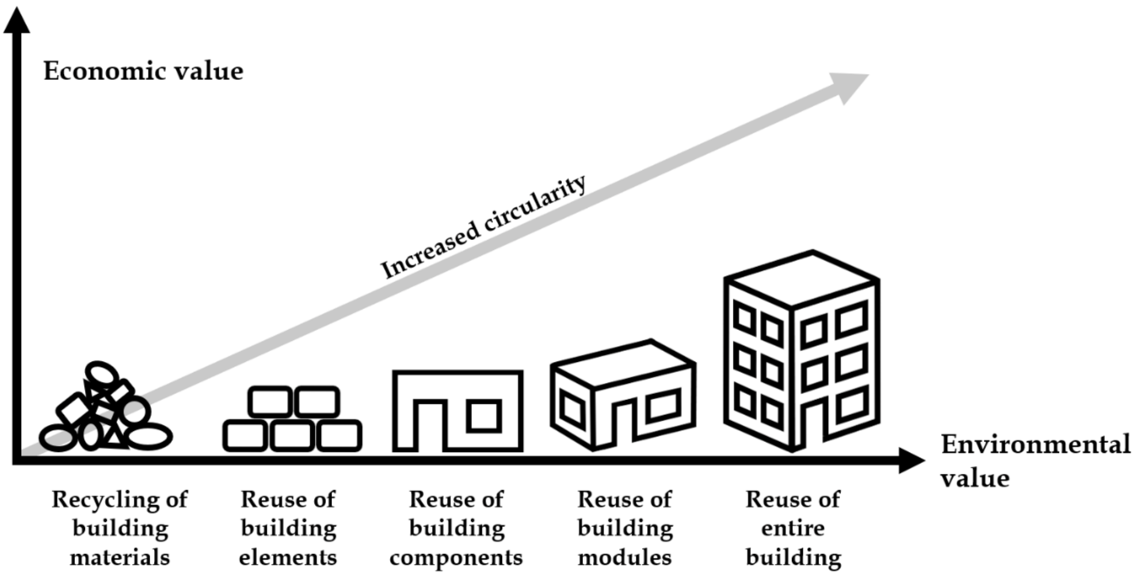

Figure 3. Conceptualization of the value of recycling and reuse degree. Adapted from Eberhardt et al., (2019).

One CE practice that has been proven to improve environmental and economic sustainability is design for disassembly (DfD) (Adams et al., 2017; Eberhardt et al., 2019). Instead of recycling building materials at the end of buildings' life cycle, DfD aims to reuse buildings' structures. Eberhardt et al. (2019) conducted a case study of a Danish office building that was designed to disassemble to quantify its potential economic and environmental benefits. The study found that DfD leads to greater economic and environmental benefits in comparison to traditional recycling and disposal of materials. However, despite being a significantly more sustainable option than recycling, the benefits of reuse are only realized upon retrieving materials and components from the building at its initial end of life. As buildings are usually long-lived products, this misfits with the industry's typical endeavor in generating short-term profit. Hence, Eberhardt et al. (2019) suggest that in order to implement CE in the construction industry successfully, a balance must be found between long-term sustainability goals and short-term economic goals.

While recycling can decrease the waste management costs and reusing building materials decreases the demand for virgin materials, procuring recycled or reused building materials can also be economically beneficial. Sustainable procurement means incorporating specifications and criteria into procurement practices that aim at improving environmental, social, and economic sustainability through resource efficiency, improved quality of products and services, and cost optimization (Yu et al., 2020). According to Karhu & Linkola (2019), the construction industry in Finland has developed standard CE criteria for procurement and purchasing organizations in the building construction sector. However, studies regarding the implementation of sustainable procurement strategies within the construction industry are still very limited (Yu et al., 2020). Witjes & Lozano (2016) proposed a procurement framework that improves resource usage efficiency through recovery. The framework is based on close collaboration between procurer and supplier, in which the experience gained by both parties through, e.g., research and development collaboration improves their contribution to CE and simultaneously provides economic benefits. While the study was not industry-specific, it demonstrates that, in general, cooperation through the procurement process can lead to several environmental and economic benefits. Winkler (2011) pointed out that improved cooperation within the supply chain can increase competitiveness and profitability, improve environmental and economic performance and increase companies' value.

CE can generate higher revenues through additional sales and higher unit prices (EMF, 2015a). Additional sales can occur in a similar manner as in the case analysis by Ranta et al. (2018): by selling recycled materials or materials that have been partly made from recycled materials. Waste management company often takes care of the processing of recycled materials and possibly pays construction company for valuable materials, such as metal scrap, which makes it important to collect them separately also from an economic point of view. While circular advantage could increase a construction company's chances to win new contracts, circular procedures can also increase unit prices. Higher unit prices and other economic effects can be assessed either separately or in one value. They can be assessed directly for customers instead of assessing them for the company, which can yield higher revenues for the company (EMF, 2015a).

CE can create several economic benefits and value creation opportunities for a construction company. However, many of them are site-specific and depend on factors such as type of material, transport distances, and economic and political context (Ghisellini et al., 2018). Applying CE practices can also cause a whole set of economic costs, especially at the beginning of implementation, due to investments in circular ways of creating value. Examples of these include increased labor costs, increased capital expenditure, and increased material costs (EMF, 2015a). The importance of cooperation was discussed in subchapter 2.2.2. mainly from the perspective of environmental sustainability. To achieve both environmental and economic sustainability, it is important that different stakeholders across the supply chain are able and willing to pursue CE as a common long-term goal instead of focusing on their individual short-term profit-making (Eberhardt et al., 2019). Cooperation between different actors within the supply chain, together with long-term investments, can lead to greater overall benefits than acting alone for individual gains (Eberhardt et al., 2019).

There are few papers that have focused on how to evaluate and measure the success of CE implementation within the construction industry (Nuñez-Cacho et al., 2018; Rodríguez et al., 2022). However, those have solely focused on environmental impacts and the success of transitioning to CE, while economic impacts have been mainly ignored. Economic sustainability is an essential part of successful CE implementation, as discussed earlier. Monitoring and measuring of economic impacts of implemented CE practices are essential to evaluate the success of CE implementation from an economic perspective. However, no existing studies are focusing on the measurement of the economic impacts of CE implementation.

3 DATA AND METHODOLOGY

This section presents and explains the research methodology used in this thesis as well as the scope of the study. The first chapter describes the chosen research method in relation to the scope of the thesis. In the second chapter, the chosen data collection method is justified, and the whole collection process is explained. In the last chapter of this section, the data analysis is explained.

3.1 Research design and strategy

The first methodological choice was to choose a suitable research method for the study. The main types of research used in social studies are qualitative research, quantitative research, and multi-method research, which combines the first two. Qualitative research and quantitative research are usually not defined individually but rather described in comparison with each other (Eriksson & Kovalainen, 2008). In general, data used in qualitative research is usually based on meanings expressed through words; when on the contrary numerical data is used in quantitative research (Saunders et al., 2009). Qualitative approaches are typically used to understand and interpret certain concepts and gain in-depth insights into unstructured problems, whereas quantitative approaches typically deal with explanation, testing of hypothesis, and statistical analysis (Eriksson & Kovalainen, 2008). As the main goal of the thesis is to gain insight into the economic impacts of implemented CE practices, a qualitative approach was seen as the most suitable option for this study. Qualitative approaches' suitability for research that aims for a more holistic understanding of phenomena that is rather weakly understood prior to the current study further affirms its suitability for the subject of this Master's Thesis.

According to Eriksson & Kovalainen (2008), there are two basic research models: deductive reasoning and inductive reasoning. In deductive reasoning, the researcher starts by developing a theory and/or hypothesis from what is already known about the phenomenon under study. The hypothesis is then subjected to a test through empirical examination (Saunders et al., 2009). In inductive reasoning researcher first collects empirical data and then develops a theory based on gathered data. Briefly said, in induction, the theory is followed by data, and in deduction, data is followed by theory. Deductive reasoning is often suitable for a research topic on which there already exists plenty of data from which a hypothesis can be developed (Saunders et al., 2009). Inductive reasoning, on the other hand, is more suitable for a topic on which there is a lack of existing data. Eriksson & Kovalainen (2008) imply that the strict deductive model is unsuitable for qualitative business research. In fact, neither one of these research models is typically used alone; instead, researchers usually use both in different phases of their study. Combining induction and deduction in different phases of one study is called abduction in literature. Eriksson & Kovalainen (2008, p. 23) describes it as *"the process of moving from the everyday descriptions and meanings given by people, to categories and concepts that create the basis of an understanding or an explanation to the phenomenon described"*.

Some characteristics of deductive reasoning are applied in this research, especially in the second chapter, which establishes the theoretical framework on which the primary data collection process is based. In this theoretical framework, there are some characteristics of theory formation, but the aim of the chapter is not to develop a comprehensive theory or hypothesis but just to provide the reader with knowledge of the subject under study before the empirical part of the study. Nevertheless, the research as a whole can be seen leaning more towards inductive reasoning because the aim is not to test a ready hypothesis but rather gain insight into the economic impacts of implemented CE practices.

3.2 Data collection process

As the aim of this Master's Thesis is to examine different CE practices that Finnish construction companies have implemented into their operations, targets related to those practices, and, first and foremost, their economic impacts, the type of the research can be described as exploratory. According to Saunders et al. (2009), exploratory research can be conducted by (1.) interviewing 'experts' in the subject, (2.) conducting focus group interviews, or (3.) a search of the literature. This qualitative study consists of two of the above-mentioned ways of conducting exploratory research. The existing literature from the relevant fields was explored to provide a theoretical framework for the empirical research phase. This secondary data was collected from various scientific papers and other reliable publications related to the topic of the study and is presented in Section 2 of this thesis. Interviewing 'experts' in the subject was deduced to be the most effective way to gain primary data from the companies in the chosen line of business. One particular reason for this data collection method was that, according to Hair et al. (2015), interviews are a suitable way of collecting data when dealing with complex issues.

There are several different types of interviews, varying from highly structured ones that use standardised questions to unstructured conversational style interviews (Saunders et al., 2009). Different types of interviews are commonly categorized according to their level of structure into three categories: structured interviews, semi-structured interviews, and unstructured interviews. Structured interviews are used to collect quantifiable data with questionnaires that are based on a predetermined and standardised set of questions. Unstructured and semi-structured interviews, on the other hand, are non-standardised, meaning that the researcher can have a list of themes and questions to be covered or at least a clear idea about the aspects that he or she wants to explore instead of predetermined and standardised questions (Saunders et al., 2009).

Using semi-structured interviews was chosen for this thesis as it was seen as the most suitable type of interview when considering the topic and the aim of the study. Furthermore, semi-structured interviews are frequently used in exploratory research, which further supports its adequacy for this Master's Thesis (Saunders et al., 2009). Themes and pre-designed questions (Appendix 1.) were created prior to actual interviews to guide the interviews in the right direction and to keep the conversation on the wanted topics. The interview outline consisted of five main themes, each composed of four to six questions and possible sub-questions. The first theme considered the background information of the interviewee and the company she or he works for. The second theme explored the interviewees' view on CE in general and how the concept is acknowledged in the company at a strategic level. The third theme dived into an operational level and explored CE-related practices that have been implemented in interviewees' companies. The fourth theme considered the economic impacts of implemented CE practices, consequently seeking an answer to the main research question. Finally, the fifth theme explored measuring the economic impacts of implemented CE practices. Due to the flexibility of semi-structured interviews, the researcher was able to use his discretion to pay closer attention to the most important subjects by, for example, asking additional questions about issues that were the most essential concerning the research questions.

Careful consideration was given regarding choosing suitable interviewees for the interviews to ensure the high quality of the data for the study. According to Saunders et al. (2009), the quality of the data is directly linked to the quality of the contributions from participating interviewees. Therefore, interviewees were chosen from large construction companies operating in Finland that have incorporated sustainability-related values and targets into their strategy and operations. The companies' turnover ranged from a few hundred million euros to a few billion euros, and they employed a few hundred to a few thousand workers in Finland in 2020. Companies' websites, researcher's personal networks, and the social networking site LinkedIn were used to find suitable participants for the interviews. The interviewees were contacted by email. All employees who agreed to participate in one-on-one interviews are 'experts' working in positions in which they are constantly dealing with topics related to environmental sustainability. To further ensure interviewees' competence to participate in the study, specific questions about their understanding of the key concepts regarding CE were asked. A total of seven employees from seven different construction companies were interviewed between December 2021 and January 2022. A description of the interviewees is presented in Table 1. Their roles in the organizations have been simplified to ensure interviewees' anonymity.

Table 1. A description of the interviewees.

No.	Company	Interviewee	Duration of the interview (min)
1	Company A	Environmental Specialist	59 min
2	Company B	Sustainability Manager	48 min
3	Company C	Safety and Environmental Manager	46 min
4	Company D	Sustainability Specialist	45 min
5	Company E	HSE Manager	63 min
6	Company F	Environmental Manager	60 min
7	Company G	Development Manager	72 min

Due to the ongoing COVID-19 pandemic and varying geographical locations between the researcher and the interviewees, the interviews were carried out using video communications platforms Zoom and Microsoft Teams. All the interviews were conducted in Finnish, as all the interviewees spoke Finnish fluently. This was done particularly to ensure that all the interviewees would be equally capable of verbally expressing their thought, views, and opinions as clearly as possible. Consequently, aiming to minimize the possibility of misconception and improve the quality of the data. The privacy policy concerning the interviews was explained to the participants prior to the actual interviews. The researcher explained that all the data collected in the interviews would be presented in a way that companies' and participants' anonymity would be preserved. Also, permission to record each interview to be later transcribed was asked from every participant.

3.3 Data analysis

According to Saunders et al. (2009), there is no standardized approach to the analysis of qualitative data. Data analysis is a complex and important part of qualitative research (Nowell et al., 2017). When conducting data analysis, the researcher has a great responsibility in making decisions about coding and theming the data. Transparent and clear communication of how data analysis has been conducted is central in evaluating the trustworthiness of the research process (Nowell et al., 2017). Thematic analysis, which is referred to as a *"foundational method for qualitative analysis"* by Braun & Clarke (2006, p. 78), is used in this thesis to identify, analyze and report themes within the primary data. Various advantageous features of thematic analysis support its suitability as a data analysis method for this Master's Thesis. The most prominent feature of thematic analysis is its flexibility: it can be used for various kinds of data sets, sample sizes, and methodological approaches (Clarke & Braun, 2017; Saunders et al., 2019). It also offers a systematic approach to analyzing qualitative data by providing a logical way to analyze data (Saunders et al., 2019). According to Braun & Clarke (2017), thematic analysis can produce trustworthy findings and is also easily accessible and rather easy method to learn.

The main purpose of thematic analysis is to search for meanings, themes, and patterns occurring in a data set (Saunders et al., 2019). In this thesis, the data set consists of transcribed audio recordings from the interviews. The goal of the approach is to transform a large amount of complex data into a short list of themes that are relevant to the study. There are varying guidelines regarding how to carry out thematic analysis, but generally, they consist of the same elements. In this thesis, the researcher follows the procedure outlined by Saunders et al. (2019). They divide the procedure into four elements that are (1.) Becoming familiar with the data, (2.) coding your data, (3.) searching for themes and recognising relationships, and (4.) refining themes and testing propositions.

Becoming familiar with the data is probably the most laborious phase of conducting a thematic analysis, especially when transcription is done individually by the researcher, as how it was done in this case. Besides transcription, the researcher re-read the transcribed interviews several times to ensure his familiarity with the primary data. Saunders et al. (2019) note that the four phases do not occur in a linear progression but rather in a concurrent fashion, meaning that, for example, the researcher becomes more and more familiar with the data during the whole procedure of conducting a thematic analysis.

After starting to feel somewhat familiar with the data, the researcher moved on to the coding phase while still getting more familiar with the data. The coding started by searching for interesting words and phrases that seemed relevant in relation to the research questions. Those words and phrases were then labelled with codes that describe or summarize the meaning of the unit of data in question. Coding is an essential part of the procedure since it enables the researcher to gain a better understanding of the complex data by categorising it with similar meanings (Saunders et al., 2019). Codes are the most basic elements of the information or data that can be regarded as meaningful to the phenomenon under study (Braun & Clarke, 2006). The total amount of initial codes in this thesis was 260, and approximately 30 to 50 codes were generated from each transcribed interview. Coding essentially allows the researcher to compose units of data that have similar meaning into groups that are comparable with the rest of the units of data ultimately preparing him or her to move on to the next phase of the analysis (Saunders et al., 2019).

The coding phase was followed by a stage that Saunders et al. (2019) calls searching for themes and recognising relationships. This means that the researcher starts to look for reoccurring themes and patterns from the list of codes that he or she has created. This, of course, is something that the researcher pays attention to already during the coding phase, meaning that the two phases naturally overlap with each other. Codes with similar meanings are collated into broader themes (Braun & Clarke, 2006). In this thesis, the first theme-forming task was to divide the codes in accordance with the three research questions. This meant that the codes were divided into three extensive categories: 1. Implemented CE practices, 2. Economic impacts associated with CE, and 3. Measuring of economic impacts of CE. After the initial categorization was done, the researcher proceeded to form themes from codes within these three categories. A theme is typically a category that involves several codes that are to some extent alike and have a similar meaning.

The fourth and final phase of conducting a thematic analysis, according to Saunders et al. (2019), is called refining themes and testing propositions. Sixteen potential themes were formed from the codes associated with the first sub-question that addresses implemented CE practices. These themes were then carefully examined through a refining process, after which seven themes were considered relevant in relation to the research question. Besides defining which codes were relevant in relation to the research question and which were not, the refining process involved reviewing all the codes and primary data related to them, as well as checking for potential overlapping. The seven themes were then further divided into three categories that are in line with the theoretical framework of this thesis. These categories were also created to make the data organized and to make it easier for readers to gain a clear picture of the results of this thesis.

Regarding the main research question, or in other words, economic impacts associated with CE, ten potential themes were formed. After a careful refining process, similar to the one mentioned above, eight themes were found to be pertinent. The eight themes were further divided into three separate categories for the same reasons as the themes discussed above. The second sub-question covered measurement of economic impacts of CE, and six potential themes were formed from codes that were associated with measurement. However, after the refining process, only two of those six potential themes were seen to be relevant to the second sub-question. All the themes and categories are illustrated in Figure 4.

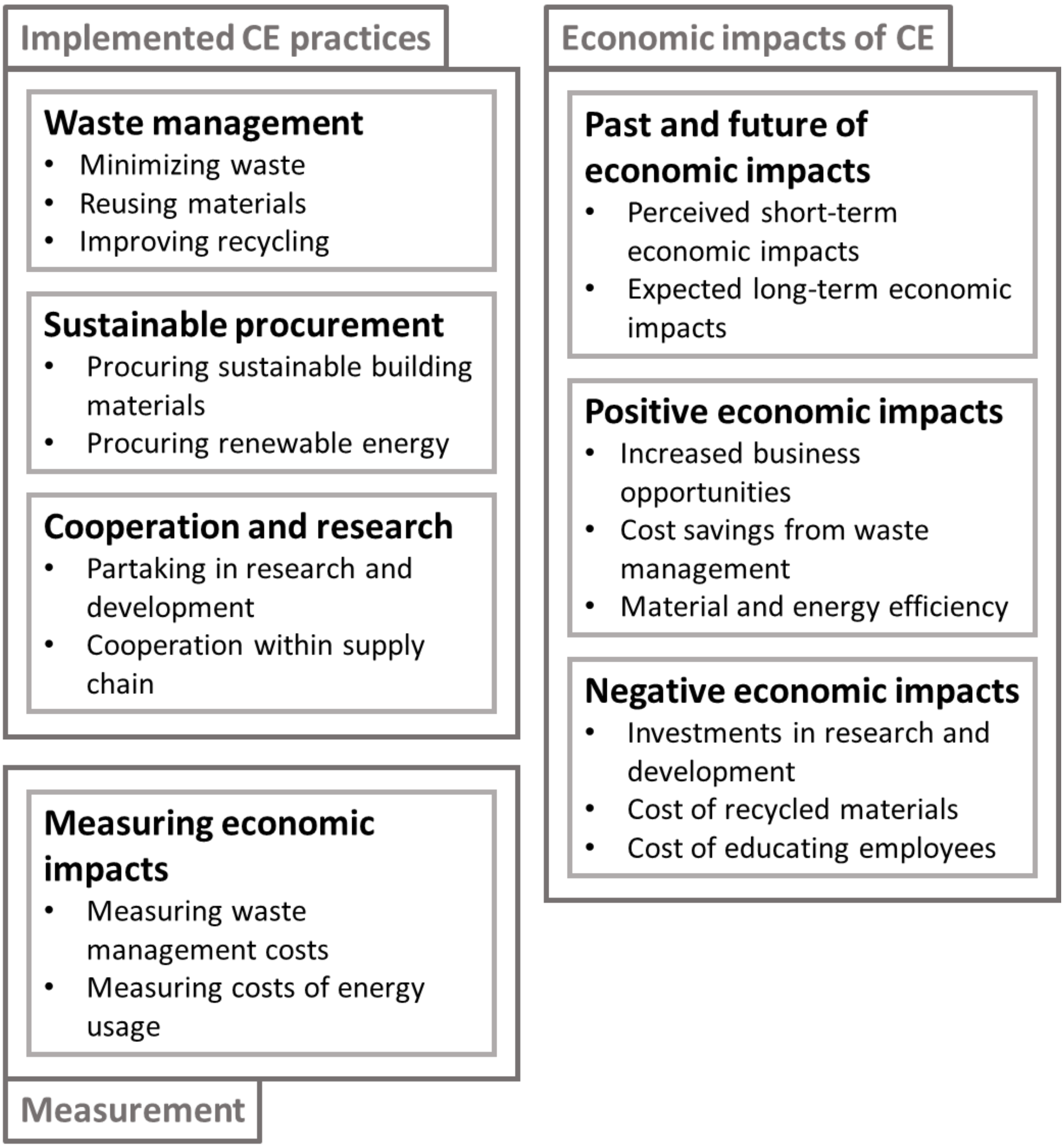

Figure 4. Illustration of themes and categories derived from codes.

4 RESEARCH FINDINGS

This section presents the findings that were made during the empirical research phase. The section is divided into three chapters in accordance with the research questions. The chapters are further divided into subchapters that cover the findings associated with each research question in detail. The first chapter discusses findings that are related to the first sub-question: What kind of CE practices Finnish construction companies have implemented in their operations? The second chapter covers the findings that are associated with the main research question: What kind of economic impacts implemented CE practices have in construction companies that operate in Finland? Finally, the third chapter discusses findings related to the second sub-question: How economic impacts of implemented CE practices and targets related to them are measured in Finnish construction companies?

4.1 Implemented Circular Economy practices

This chapter discovers what kind of CE practices Finnish construction companies have implemented into their operations. The chapter is divided into four sub-chapters from which three correspond to categories in which the themes related to the first sub-question are divided. The fourth sub-chapter provides information about different drivers and limitations that are often associated with CE implementation in construction companies.

4.1.1 Waste management

Waste management was brought up in every interview, and it is widely seen to be associated with CE. It was also regarded as the most concrete CE practice at the construction site. The three themes that the broader category contains are (1.) Minimizing waste, (2.) Reusing materials, and (3.) Improving recycling. The three themes are directly uniform with the three most favoured options of the waste hierarchy. The hierarchy of priorities was well understood by the interviewees, and the three stages of the waste hierarchy were not seen as equal between each other but rather in a similar hierarchical order as in literature.

Minimizing waste was mainly associated with an aim to avoid ordering or procuring more materials to the site than what is needed. During the construction phase, in practice, this means that employees who are procuring materials to the site have up-to-date knowledge regarding on-site inventory and have made a precise calculations prior to ordering materials. In addition, careful planning and optimization of schedules, logistics, and storage are required to minimize the amount of waste. For example, appropriate storing of materials on-site reduces the possibility of them being damaged. Taking good care and maintaining different tools and equipment further avails the creation of a closed-loop. During the design and planning phase, the focus is increasingly on creating closed material loops or at least extending their lifecycle to minimize the amount of waste.

"When addressing the issue on-site, we strive to avoid ordering excess materials to minimize the amount of waste generated" – Interviewee 3

According to the waste hierarchy, reusing materials is the second option in order of priority. In terms of efficiency and sustainability, the most favourable place to reuse materials is on the same site, whereas relocated reuse is a secondary option. Both options came up and were discussed in several interviews. Especially, transportation of large amounts of heavy materials, such as landmasses, is expensive and emits great amounts of greenhouse gas emissions, which is a reason why companies strive to reuse them on-site. If materials cannot be utilized on-site, they are reused, depending on the geographical location, at other sites nearby or possibly sold to be used by someone else either for the same or other purposes. The different degrees of reuse were highlighted by some of the interviewees. The possible reuse of building modules and components was recognized to have a higher economic and environmental value in comparison to reusing building elements or materials.

"We can, for example, reuse crushed concrete on-site as a base for parking place" – Interviewee 1

Improving recycling was seen as an important and topical subject more or less by all interviewees. For various reasons, plenty of waste is still generated during the construction phase, and all the companies have set targets to improve their recycling rate. There were differing views regarding whether improving the recycling rate is considered a practice fully associated with CE or if it is just done to meet the legal requirements. Legal requirements, in general, were seen as a driving factor for CE implementation in Finnish operational environment, especially affecting endeavours regarding improvements in recycling. Either way, several actions have been taken to achieve a higher recycling rate at sites. In several companies, ambitious pilot projects were in place that aimed at a much higher recycling rate than what the legal requirement is.

"This year we have set ambitious goals regarding our recycling rate. We have started several piloting projects, where we strive to produce 0 percent of mixed construction waste" – Interviewee 7

4.1.2 Sustainable procurement

Paying attention to sustainability when procuring materials and energy was mentioned by several interviewees in association with implemented CE practices. Especially, procuring reused and recycled materials were found to be very closely associated with CE. Several companies have set targets to reduce their carbon footprint, and low-carbon materials and energy are seen as very interesting and attractive.

By procuring sustainable building materials, construction companies aim at replacing traditional building materials that are virtually always made from virgin raw materials with materials that are either reused or partly or entirely made from recycled materials. The interviewees brought up several barriers and limitations regarding the use of these materials, and those are further discussed in sub-chapter 4.1.4. Also, even though there is clearly an increasing demand for recycled materials, the supply of these materials is still very limited. Recycled raw materials used in elements and components that are already available on the market can originate either from the construction industry or some other industry. Some examples that interviewees mentioned are low-carbon concrete elements and glass wool. Low-carbon concrete elements are partly made from ground-granulated blast-furnace slag, which replaces traditional cement. Ground-granulated blast-furnace slag is generated as a side stream in iron and steel-making. Glass packages, such as bottles and jars, can be utilized in glass wool production, and glass wool from demolition sites can be further recycled and utilized in the production of blown wool. Albeit procurement departments of the companies are increasingly paying attention to the sustainability of procured materials, clear procedures have not been implemented in their practices at this point.

"Our procurement department is aware of the situation, and they pay attention to sustainability on daily basis when they are making decisions" – Interviewee 2

Procuring renewable energy was discussed in a few interviews. Interviewees addressed procurement of renewable fuels and the use of renewable electricity. Renewable fuels are used to replace fossil fuels in all kinds of heavy construction equipment, such as excavators and tower cranes. Renewable electricity is naturally used to replace electricity that is produced by using fossil fuels.

"We continually monitor our fuel consumption and investigate financially viable options to gradually replace fossil fuels with renewable alternatives" – Interviewee 1

4.1.3 Cooperation and research

All the interviewees saw that plenty of research and development work is still required to implement CE in the construction business comprehensively. Also, there was a consensus regarding the importance of cooperation when taking the next step toward more circular construction. The two themes that are discussed in this sub-chapter (1.) Partaking in research and development and (2.) cooperation within the supply chain partially overlap since there are several development projects within supply chain networks. However, they also have dividual qualities, for which reason they are addressed separately. For example, there are often participants involved from outside of the supply chain in research and development projects. Whereas cooperation within the supply chain consists of various other forms of cooperation than only research and development projects.

Several research and development projects were discussed with the interviewees. Many of those projects aim to find solutions to limitations associated with CE implementation (which are discussed in detail in sub-chapter 4.1.4). According to the interviews, the circularity of construction materials was the most researched topic. Some examples that were mentioned about the topics of these projects were: how different building materials can be recovered and reused more efficiently, how to develop materials and elements that have a smaller carbon footprint, and compiling a databank of existing low-carbon materials that already exist on the market. Concerning the topic, research and development projects had been done and were underway in cooperation, not only with suppliers but also with, for example, waste management companies and non-profit associations. Other mentioned development projects were also related to the circularity of materials, at least indirectly or partially. They were associated with subjects such as developing a digital database for low-carbon materials (the content of the materials) and mapping out alternative materials for materials that contain toxic substances to make it possible to reuse or recycle them more efficiently in the future. Some projects also took a more holistic approach and aimed at developing new innovative CE solutions. In addition to earlier mentioned participants of various research and development projects, also other stakeholders such as institutions, universities, and consulting firms were involved in some projects.

"Last year we were developing and testing a low-carbon concrete element in close collaboration with Company X" – Interviewee 7

Cooperation within the supply chain network was seen as a necessary part of CE implementation. Internal efforts toward the circularity of construction materials were regarded as quite limited if no other players from within the supply chain network were involved. Interviewees saw that if every player within the supply chain network took part in a collaborative manner to improve the circularity of the construction industry, the opportunities to achieve sustainability-related goals such as carbon neutrality would be much more realistic. Few interviewees mentioned that they had set sustainability-related requirements for their suppliers and sub-contractors. Others mentioned that similar r equirements had been set for them by contractees in construction projects where they acted as a contractor. Besides setting requirements, companies were striving to establish and strengthen cooperation with different supply chain participants by simply communicating with them in a more frequent manner.

"Waste sorting on-site can be considered as an internal activity, but everything else that can be associated with circular economy happens pretty much in a co-operation with cooperation partners, especially suppliers" - Interviewee 2

4.2 Economic impacts

This chapter discusses findings related to the main research question: What kind of economic impacts implemented CE practices have in construction companies that operate in Finland? The chapter is divided into three sub-chapters. The first sub-chapter focuses on perceived short-term economic impacts and expected long-term economic impacts. The second sub-chapter explores the positive economic impacts that are associated with CE implementation, whereas the third sub-chapter focuses, on the contrary, on the negative economic impacts of CE implementation.

4.2.1 Past and future of economic impacts

Two distinct themes are discussed in this sub-chapter. First, perceived short-term economic impacts of implemented CE practices and later, how interviewees expect the economic impacts associated with CE implementation to be in the long-term. Most interviewees saw that implemented CE practices had had a positive impact on the company's finance this far, while few of them saw that in the short-term, there had been more costs associated with CE implementation in comparison to returns. However, when implementing CE practices was seen as an expenditure, the extra costs often end up to the client and further to the end-user. One interviewee said that when taking part in competitive bidding regarding some new construction project, precise calculations are always done prior to it to make sure that the project is profitable for the company. Consequently, any extra costs that end up as payables for the construction company must be something unexpected that was not taken into calculation. Also, sometimes premeditated monetary investments are made to either gain some other kind of value or in order to gain greater monetary profit over time. Generally, the perceived short-term economic impacts of implemented CE practices seemed really challenging to estimate since so many variables are associated with them. Also, they were not seen to be very significant when it comes to decision-making. In summary, short-term economic impacts of CE implementation are seen to lean more towards beneficial than disadvantageous.

"When thinking about our operational business on-site, I would say that they (economic impacts of CE) have probably mostly been positive" – Interviewee 6

Interviewees' views regarding expected long-term economic impacts were more coherent. Nearly everyone assumed that implementing CE into the company's operations would be profitable in the long run. As it was widely perceived that CE implementation within the industry is still in its infancy stage and, therefore, further investments in research and development are required, it was believed that in a timespan of five to ten years from now, several CE solutions that are now financially not viable will be by that time. It was also assumed by a couple of interviewees that in the near future economic factors, such as reducing prices of recycled building materials, will steer the industry rapidly towards greater circularity. Overall, investments in activities that are in line with CE principles were seen to yield profits in the long-term.

"I believe that when we do this work (to improve circularity) and keep doing it persistently, it will return the investments in it manifold in the future" – Interviewee 1

4.2.2 Positive economic impacts

This sub-chapter addresses three themes that were seen as a positive economic impact of implementing CE in the operations of construction companies. They are (1.) increased business opportunities, (2.) cost savings from waste management, and (3.) material and energy efficiency.

All the interviewees recognized that the whole industry and the business environment are steadily shifting from a linear economic model toward a circular model. According to one interviewee, when the whole industry is in a transition towards CE, it is necessary for the companies to do so as well if they want to survive. On the positive side, those companies that strive to be forerunners and successfully implement circular procedures to their operations often gain a competitive advantage over those that are sluggish to transform. One practical example of this is that they have a higher chance of winning a bidding competition because they are more likely to fulfil a wider variety of sustainability-related requirements from contractors and clients. Also, the level of corporate sustainability affects the chances of getting funding from investors. So, when a company's operations are well in line with ESG (environmental, social, and corporate governance) criteria, they generally get funding with a lower interest rate. CE is seen to affect the fulfilment of the criteria directly and indirectly.

"One of the positive impacts is that clients are nowadays also increasingly interested in these matters (CE and environmental sustainability), which increases our chances of winning competitive biddings" - Interviewee 6

High standard waste management was seen to decrease costs and therefore have a positive economic effect. Preventing waste generation naturally decreases costs because there is no need to manage something that does not exist.

However, effective recycling was seen as the most distinct CE practice that has a direct positive economic impact. Several interviewees had recognized that waste management costs were significantly lower on sites with higher recycling rates than those where a majority of generated waste ended up in energy recovery. Improving the recycling rate requires some investments in the training of the employees and affects on-site logistics, but it was still considered to be economically efficient.

"With effective waste management, we gain positive economic impacts… And actually, the economic side of it is one of the drivers why we strive to consistently improve it. We also understand that the price of mixed waste has been rapidly increasing lately and will likely increase in the future" - Interviewee 3

Efficient use of materials and energy were seen as obvious economically positive effects of CE. The fewer materials or energy is used, the fewer costs there will be occurring from them. In practice, this is done, for example, by instructing employees on energy-efficient working methods and investing in energy-efficient tools and machines. Efficient use of materials is closely associated with the reuse of materials and avoiding excess materials.

"Material efficiency and energy efficiency are self-evident, less used materials and energy equals to less costs" – Interviewee 6

4.2.3 Negative economic impacts

In this sub-chapter, three themes that were seen as a negative economic impact of implementing CE in the operations of construction companies are discussed. These themes are categorized as negative economic impacts in contrast to positive economic impacts that were discussed above, but rather than being negative; the themes are associated with expenses. So, rather than economic impacts being actually negative or harmful, they cause costs that are often associated with planned investments. The three themes are (1.) Investments in research and development, (2.) Cost of recycled materials, and (3.) Costs from assimilating new procedures.

As mentioned earlier, many interviewees said that they are taking part in various research and development projects. In addition to cooperative development projects, companies are also developing their internal procedures. These research and development projects that are carried out either internally or in cooperation with stakeholders naturally require investments. Many interviewees mentioned that primarily working time of specialists and experts is invested in these projects, but sometimes they also require direct funding. Working time of white-collar workers, of course, causes costs for the company as well. However, all the time and money that is invested in the research work is expected to pay back either monetarily in the future or in some other form of value now or later.

So, in contrast to negative impacts, these economic impacts are often seen as necessary investments that yield in the long run.

"In development projects, the costs are usually calculated precisely… expected calculated expenses usually consist of employees' working hours that are used in particular CE-related research project." – Interviewee 7

The relatively high cost of recycled building materials was seen to limit their use and hinder CE implementation. Because various building components and elements which are manufactured from recycled materials and are currently available on the market are more expensive than traditional options, companies are still often forced to go with the traditional option. Traditional building materials have been developed for decades, whereas sustainable alternatives are new to the market and still often require some finetuning to succeed against the traditional ones. The same price dilemma is associated with renewable energy in comparison to non-renewable energy. Most interviewees had a quite positive view regarding the future of these controversies: the price of virgin materials was expected to increase in the future due to the depletion of natural resources, and the price cap between sustainable and traditional options was expected to shrink and disappear in the near future. However, as of now, the use of sustainable materials is still often associated with higher costs in comparison to using traditional options.

"I think that still at this moment those (sustainable) products are rarely cheaper than traditional products that have been developed for decades" – Interviewee 3

Implementing new procedures into an organization requires new skills and knowledge from employees. Providing the knowledge and skills requires the training of workers. Providing the required training either costs money directly if it is provided by an external authority or at least the working time of an internal specialist, which means indirect monetary cost. Training the employees to recycle is a good example of education that causes costs. In addition to costs occurring from training, implementing new procedures also often temporarily decreases productivity when procedures are being assimilated by employees, which indirectly results in costs. Even though implementing new procedures in an organization requires training of workers, keeping employees' knowledge and skills up to date with everything related to their job description was seen as an obligatory task.

"Investments are often associated with improving the skills and knowledge of the people… transforming employees' ways of acting is rather challenging and requires time and money" – Interviewee 2

4.3 Measuring economic impacts

This chapter focuses on the results concerning the second sub-question: How economic impacts of implemented CE practices and targets related to them are measured in Finnish construction companies? The chapter is divided into two subchapters according to the two themes that were identified to be under the category of measuring economic impacts. The themes are (1.) Measuring waste management costs and (2.) Measuring costs of energy usage.

4.3.1 Measuring waste management costs

When measuring the economic impacts of CE were discussed with the interviewees, waste management turned out to be the most common object of the discussion. Waste management costs were monitored in all companies, but the way in which they were monitored varied. Generally, waste management costs were monitored per site and compared to recycling rate and possibly to the same data from other sites. One interviewee explained that per site, waste management costs and recycling rate are monitored by a construction site manager, and at first hand, he or she is responsible for any modifications regarding the performance of waste management. Specialists from the sustainability department also monitor the data, not in detail, but rather by scanning it in case of any outliers. Comparing waste management data from different sites were seen as an effective way to find tools to improve waste management in those sites where there were shortcomings in the recycling rate. One interviewee mentioned that they are monitoring waste management costs in comparison to the built square metre.

"We monitor our waste management closely because we have to report some of the data to the public authority. Very detailed data is available directly from waste management companies, so it is easy to monitor the costs associated with it… and perform possible changes" – Interviewee 1

4.3.2 Measuring costs of energy usage

Few interviewees mentioned that they are measuring costs that are associated with energy usage. Energy usage was measured in several different ways, of which some are not associated with CE and its economic impacts. Energy usage per built square metre, for example, is not directly associated with CE-related costs, but when there is a comparison between renewable energy and non-renewable energy added into an equation, it is clearly associated with CE. All measuring that considered the economic impact of energy use in relation to CE was measured by comparing sustainable option to traditional option. However, this did not seem like a very common practice among the companies because it was only brought up in two interviews.

"Regarding energy usage, we monitor different primary energy sources that we use, emissions associated with them… they are then put into perspective with our operations, for example, by comparing them to square metres built and company's turnover" – Interviewee 6

5 DISCUSSION

In this section, the research findings are discussed with respect to the theoretical framework of this thesis presented in Section 2 and the research questions. The first chapter focuses on research findings related to the first sub-question that addresses implemented CE practices in construction companies operating in Finland while simultaneously reflecting on the literature review. The second chapter discusses the findings concerning the main research question. It aims at bringing forth economic impacts associated with CE recognized in this thesis in relation to the earlier literature on the subject. Similarly, the third chapter focuses on research findings associated with measuring the economic impacts of CE, as it is the second sub-question of this Master's Thesis.

5.1 Implemented Circular Economy practices

This chapter discusses implemented CE practices in construction companies operating in Finland by reflecting on the previously introduced literature. The findings of this thesis indicate that the overall current state of CE in construction companies operating in Finland is very well in line with the previous literature discussing the implementation of CE in the construction industry. Before going into the details of the implemented CE practices, general comparison is made between the level of CE implementation in participated companies and how the level of CE implementation within the industry is seen in current scientific literature. Hossain et al. (2020) described that the effective implementation of CE is still in its infancy stage, albeit interest in the concept has grown exponentially during the past five years. Generally, the findings of this study align with their view since various CE-related possibilities and opportunities that enable a more holistic implementation of CE were recognized by the interviewees. However, there still existed several impediments to their implementation. This is further supported by the fact that implemented CE practices are still primarily associated with waste management, which is a widely studied subject in the field, but indicates that the focus is still more on treatment rather than prevention as it has been in the earlier literature (Ghisellini et al., 2016). However, as the literature outlines that the interest in CE and its more profound implementation is increasing (e.g. Benachio et al., 2020; Hossain et al., 2020), it was obvious that most interviewees were very enthusiastic and interested in the concept and all the opportunities it bears.

An interesting observation was made regarding the macro level and, in more detail, the legal environment in which the construction companies are operating. It was concluded in the literature review that the legal environment is steadily transforming to become more and more favourable regarding CE implementation in the construction industry. According to interviewees, the legal environment was seen as one of the driving forces to implement CE practices. So, rather than just creating a favourable environment for CE implementation, the legal regulations were seen to push the industry towards circularity. On the other hand, it is worth noticing that because of the legal requirements, some CE practices are done in compliance with the law and other regulations rather than for some other reasons. Even though the aim of this thesis is not to investigate different motives that drive CE implementation, this is still something worth keeping in mind when implemented CE practices are discussed because all actions to improve a company's circularity are not made with sustainability endeavours in mind, but often for various different kinds of reasons.

The research findings suggest that there were, in total, seven different implemented CE practices that were highlighted in the interviews. Three of them were associated with waste management and were waste minimization, reusing materials, and improving recycling. Two of the implemented CE practices were associated with sustainable procurement, namely, procuring sustainable building materials and procuring renewable energy. The last two implemented CE practices were partaking in research and development and cooperation within the supply chain, which were categorized as cooperation and research.

To start with, implemented CE practices associated with waste management are perfectly in line with the three most commonly used R's considered in CE-related literature. As was highlighted in the theoretical framework, there are several combinations of different R's used in CE literature, but according to the research by Kirchherr et al. (2017), recycling, reuse and reduce is by far the most used combination. These so-called 3R's are even referred to as the founding principles of CE by Ghisellini et al. (2016). There are different views regarding the correct terminology about these terms, especially about minimization versus reduction. They are used as synonyms in some contexts, but sometimes all three R's are put under minimization. However, in this thesis, these two terms are considered synonyms for each other. According to this interpretation, the three implemented CE practices correspond directly with the 3R's framework and largely also with the most desirable options of the waste hierarchy presented in Figure 2. These three CE practices that are considered mainly as an approach to more appropriate waste management are strongly linked to earlier research on CE and more recent literature has pointed out that this kind of narrow view on CE fails to demonstrate the magnitude of the whole concept (Ghisellini et al., 2016). Even though recycling and reusing are particularly seen as methods of treatment rather than prevention, they are still essential CE practices at the current level of CE implementation within the industry. Moreover, albeit being the most concrete implemented CE practices according to the interviews, these were not the only CE practices recognized in this thesis, which verifies that CE is considered in a bigger picture in participated companies.

Regarding implemented CE practices associated with sustainable procurement, materials and energy were found to be the topic of discussion. From these two, procuring recycled materials was clearly more crucial in the context of building construction. According to Adams et al. (2017), procuring reused and recycled materials is one of the key aspects of CE implementation during the construction phase, together with waste minimization and off-site construction. As many interviewees mentioned that they had set targets to reduce their carbon emissions, replacing traditional construction materials with carbon-neutral or low-carbon alternatives came across as one of the key means to achieve those targets. Several participating companies had experience procuring substitutive low-carbon building materials made either partly or fully from recycled materials. However, it seemed that many of the more advanced examples of procuring reused or recycled materials discussed with the interviewees were some sort of pilot projects. Due to various impediments, more holistic implementation of sustainable procurement practices was still largely absent. For example, employees from the procurement department were involved in development projects regarding sustainable procurement and were said to consider sustainability issues during procurement processes, but there was yet no specific sustainable procurement management system in place, according to the interviews. Procuring renewable energy, namely electricity and fuels, seemed to be an easier task to carry out since decisions had been made on a higher level, according to interviewees. When the decision is made, all there is to do is just to procure electricity and fuels in accordance with the decision.

The last two CE practices that were recognized as relevant to the first subquestion were partaking in research projects and cooperation within a supply chain network. In scientific literature regarding the implementation of CE in the construction industry, the importance of cooperation is widely highlighted. As Barreiro-Gen & Lozano (2020) emphasized, organizations are not islands but must collaborate with stakeholders to achieve the goals of CE and sustainability. All the interviewees shared this view. According to research papers, cooperation within a supply chain is particularly crucial in the construction industry to achieve more pervasive circularity due to supply chains' large size and complexity (Pomponi and Moncaster, 2017; Wrinkler, 2011). This had been noticed by interviewees, as many of the companies strived to establish and strengthen cooperation with different participants within supply chains. One fascinating insight was that many stakeholders that were said to be largely unaware of the CE concept, according to Adams et al. (2017), were actually quite aware of the concept, according to the interviewees. For example, Adams et al. (2017) considered clients unaware stakeholders, whereas interviews indicated that even CE-related requirements were coming from them in some projects. Partaking in research projects that aim to find solutions to limitations associated with CE implementation is regarded as a CE practice in this thesis. In literature, the subject is not widely discussed as a separate entity but rather together with the cooperation aspect. However, the importance of cooperation is often regarded to involve only companies that are involved in the supply chain, whereas many interviewees referred to research projects that also involved other stakeholders from outside of supply chains. Thereby, they are addressed as separate CE practices in this thesis, even though some overlap exists between them.

All above-mentioned CE practices recognized in the interviews were either very clearly highlighted in CE literature or at least discussed indirectly. In addition to those, there were a few other ways to implement CE mentioned in the literature that were not brought up by the interviewees in a way that they would have been considered relevant CE practices in this thesis. The most notable one was off-sit construction, which was mentioned as a key aspect of CE implementation during the construction phase by Adams et al. (2017). Either procedures concerning it has been implemented, but it was just not seen as clear CE practice by the interviewees, or off-site construction practices have not been yet implemented into companies' operations. Other CE practices that were not recognized as relevant in this thesis but were mentioned in the literature were associated with the customer value proposition dimension presented by Urbinati et al. (2017). Very few practices were brought up by interviewees concerning applications of shifting from pay-per-own to pay-per-use approach or payment for use- or result-oriented services instead of paying for ownership. However, these practices were not seen as relevant during the construction phase but rather were associated with the use phase. Also, the application of these practices was not discussed in CE literature concerning the construction industry but rather in association with CE implementation from a more general perspective. In conclusion, apart from off-site construction, implemented CE practices in construction companies operating in Finland are in line with CE practices that have been recognized as relevant in the literature concerning the implementation of CE during the construction phase.

5.2 Economic impacts of implemented Circular Economy practices

In this chapter, the findings of this thesis concerning the economic impacts of implemented CE practices in construction companies operating in Finland are discussed in contrast to the literature review. Discussion about CE has mainly focused on its environmental impacts, and the papers that have addressed its economic impacts often discuss them together with environmental and social impacts (Ranta et al., 2018). Since the literature about the subject is still relatively limited, this thesis aimed at investigating interviewees' views regarding the subject in a general manner before going further into details concerning separate CE practices and their economic impacts.

Findings concerning interviewees' general views about the economic impacts of implemented CE practices were divided between perceived short-term economic impacts and expected long-term economic impacts. The results show that most of the interviewees see that the economic impacts of implemented CE practices have mostly been positive in the past and are expected to be mainly positive also in the future. Regarding short-term impacts, there was more variation in the answers, and few interviewees saw that there had been more costs associated with CE implementation than economic benefits. According to Hossain et al. (2020), further economic incentives are required within the industry to boost CE-related innovation and to balance out economic downsides. This thesis shows that this observation by Hossain et al. (2020) is quite relevant, especially at the beginning of CE implementation, when there are possibly more costs associated with it. However, as most of the costs do not end up as payables for the construction company but for a client or final customer, it is unclear how those possible incentives would be divided. On the other hand, incentives for construction companies would be very welcome to boost CE-related innovation. Almost every interviewee expected the long-term economic impacts of CE implementation to be positive. This view was mostly backed up by the coherent perception that as time passes, many CE-related solutions become more affordable than they currently are, and traditional linear options end up being more expensive.

The research findings suggest three direct positive economic impacts associated with CE implementation. Namely, they were increased business opportunities, cost savings from waste management, and material and energy efficiency. A report by EMF (2015a) that discussed the economic benefits of CE implementation from a general perspective divided them into two distinct categories: cost savings from materials and increased revenues. While increased business opportunities can be associated with increased revenues -category, the two other economic benefits found in this thesis can be associated with cost savings from materials. According to the report, increased revenues typically occur from additional sales and higher unit prices. Increased business opportunities refer to situations where a company has gained a competitive advantage over other companies by being more circular and more environmentally sustainable than its competitors. This can be linked to additional sales because many interviewees had recognized that they could participate in competitive biddings where there are more sustainability-related requirements from the client or contractor. More construction projects often mean more sales. As noted earlier, additional costs still often occur from circular procedures because many of them are still in the process of development. In many cases, these additional costs can be put into the final product, which can be sold for a higher price, linking this factor to the other aspect of generating higher revenues.

Cost savings from waste management and material and energy efficiency are interconnected to cost savings from materials. While all three CE practices associated with waste management in this thesis are closely linked to cost savings from materials, efficient recycling was seen to have the most notable positive economic effect. This finding is in line with the findings of a multiple-case analysis by Ranta et al. (2018), in which it was found that in all companies that participated in their study, recycling was recognized as the main source of economic value from CE practices. Waste minimization and reusing materials are higher in the waste hierarchy, meaning that they are preferable options compared to recycling. In terms of striving to keep materials in the closed-loop and maintaining their economic value, recycling falls well behind the two preferred options. It appears that the dominance of recycling as the most important contributor to positive economic impacts over reduce and reuse comes from the great quantity of materials that are recycled. However, concerning the economic impacts, all three R's were put under cost savings from the waste management -theme in this thesis, and this is only an assumption based on the interviews. Material and energy efficiency refers to minimizing their use, which causes cost savings.

In addition to the positive economic impacts of implemented CE practices, negative economic impacts were also recognized in the interviews. As mentioned in the research findings, rather than being direct negative economic effects, they were mainly seen as costs that hinder the transition towards a more holistic implementation of CE. Namely, those themes associated with expenses were investments in research and development, cost of recycled materials, and cost of educating employees. As it was made clear in the theoretical framework, especially at the beginning of implementation, CE practices can cause various negative economic impacts due to investments in circular ways of creating value. Investments in research and development is directly interconnected with this view. Since the construction industry is still in its infancy stage when it comes to implementing CE, there is plenty of research and development work to do to take the industry to the next level of circularity. Many interviewees saw investing in research and development as necessary, and the money and time invested were expected to pay back in the future.

Costs associated with educating employees were also seen as necessary. In EMF's report (2015a), increased labour costs were seen as one economic effect of implementing CE practices to the operational level. Implementing new procedures always requires updating employees' knowledge and skills. The EMF's report (2015a) also mentioned increased material costs and those were recognized as the cost of recycled materials in this thesis. Again, because CE implementation is still in its early stage in the construction industry, many building components and elements that are manufactured from recycled materials that intend to substitute traditional materials are still under development and, therefore, more expensive than their traditional alternatives that have been on the market for a long time. However, several interviewees expected the price cap to shrink in the near future and eventually turn in favour of recycled materials. This, of course, requires more work and investments in development and possibly also an increase in the price of virgin raw materials due to the depletion of natural resources. As of now, this is widely seen as an impediment to CE implementation.

5.3 Measuring economic impacts

This chapter discusses how the economic impacts of implemented CE practices are measured in construction companies operating in Finland. The prior literature regarding this subject was found to be close to non-existent, indicating that it is unlikely that these kinds of measurement practices are in use in participated companies. Whenever measuring and indicators were discussed in this context, it usually focused on measuring circularity performance, not economic impacts. Even in those papers, it was highlighted that the literature regarding measurement is rather limited, and additional research on the topic is required. However, the research findings of this thesis suggest that the economic impacts of waste management and energy usage are closely monitored in some participated companies. Waste management costs were monitored to some extent in all participated companies, but there were differences in how that data was used. Some interviewees mentioned that waste management costs were monitored per site together with the recycling rate and that data was compared with the same data from other sites to find out where there was a need to improve the recycling rate to cut costs. Regarding costs of energy usage, the CE aspect was brought to the calculations by comparing energy usage costs between sites that used energy from renewable sources and sites that used energy from non-renewable sources. However, very limited data was gathered in this research regarding these kinds of practices.

Altogether, measuring economic impacts related to CE did not seem like a very common practice apart from monitoring waste management costs and costs related to energy usage. When interviewees were asked about measuring of economic impacts of CE, fairly few concrete measurement practices were brought up in addition to the two discussed earlier. In addition, those other measurement practices that were either already in place or still just ideas were not directly associated with the economic impacts of CE. The ones that were already in place were rather different measurement practices associated with measuring emissions. Nevertheless, most interviewees expressed their interest in the subject. Few had even noticed an apparent demand to develop measurement practices to monitor the success of CE implementation and its economic aspects. This observation has also been recognized in the literature (e.g. Hossain et al., 2020; Ghisellini et al., 2016). As the use of recycled materials was seen as an essential part of CE implementation during the construction phase, few interviewees were pondering with an idea of developing some kind of tool that could be used to measure success of transition from traditional materials to recycled ones, as well as economic impact of that transition.

6 CONCLUSION

This final section of the thesis consists of three chapters. The first one summarizes the aim of the thesis and presents the key takeaways from it. It also considers the overall contributions from this thesis to construction companies operating in Finland. The second chapter discusses the trustworthiness of this thesis and the limitations that are affiliated with it. Finally, the last chapter provides suggestions for future research within the research area covered in this thesis.

6.1 Key takeaways from this thesis

The primary aim of this thesis was to investigate the economic impacts of implemented CE practices in construction companies that operate in Finland. In addition, a secondary objective was to explore CE practices that those same companies have implemented into their operations. Finally, the thesis also aimed to observe what kind of measurement practices regarding the economic impacts of implemented CE practices are in place in those companies. Because some aspects of the subject of the study are somewhat weakly understood, especially in the chosen industry, and the aims were associated with gaining insight into these aspects, the qualitative approach was seen as a suitable research method for the study. Primary data for the study was collected by interviewing 'experts' in the subject from construction companies that operate in Finland. The qualitative data gathered through semi-structured interviews was analyzed by using thematic analysis. Through that analysis, a variety of themes were formed to answer the aims of the thesis. The results provide knowledge about the current state of CE implementation and implemented CE practices in construction companies operating in Finland. The thesis also contributes to achieving a better understanding of the economic impacts associated with CE implementation. In addition, the findings of this thesis shed light on measurement practices that are associated with the economic impacts of implemented CE practices.

Regarding implemented CE practices, the findings indicate that there are seven notable practices associated with CE during the construction phase that can be divided into three categories: waste management, sustainable procurement, and cooperation and research. Practices related to waste management stood out as the most concrete CE practices currently in use. This indicates that even though CE is understood holistically within the industry, its practical implementations are still largely associated with regenerating materials and energy from waste. Procuring sustainable materials was recognized to have a crucial role in achieving companies' environmental sustainability goals, such as carbon neutrality. However, the findings of this thesis suggest that implemented practices regarding the procurement of recycled building materials are still rather limited. Nevertheless, besides interviewees' apparent interest towards the subject, it is also a widely researched topic within the industry, which implies that the practical implementations will increase distinctly in the future. The research findings indicate that cooperation within supply chains is extensively practiced within the construction industry in Finland. This thesis suggests that implemented CE practices during the construction phase in construction companies operating in Finland are in general in line with current literature.

The results of this thesis imply that the economic impacts of implemented CE practices are mainly seen as positive by construction companies' 'experts' in environmental sustainability. Few interviewees supposed that in the short-term, there are more costs than economic benefits associated with CE implementation. However, those costs were either expected to pay back in the future (investments in research) or were expected to decrease (material costs), and long-term economic impacts were almost entirely expected to be mainly positive.

Finally, this thesis suggests that the economic impacts of implemented CE practices in construction companies operating in Finland are not measured as an ensemble. However, costs associated with waste management and energy usage were monitored by various companies. The most notable finding regarding the measurement of economic effects of implemented CE practices was that most companies were genuinely interested in possibilities regarding it, and some had even recognized a demand to develop measurement practices to monitor the success of CE implementation and economic aspects related to it.

6.2 Trustworthiness & limitations

This chapter aims to evaluate the trustworthiness of this thesis and present limitations that may influence its results. Data analysis has been characterized as the most complex part of qualitative research (Thorne, 2000). To produce a trustworthy study the researcher must address that the data analysis has been carried out precisely, thoroughly, and consistently through recording, systematizing, and disclosing the analysis methods in detail to ensure the study's credibility (Nowell et al., 2017). Throughout the whole project, and especially during data analysis, various steps have been taken to produce trustworthy data and minimize possible limitations. To achieve this during the methodological process, the researcher followed the criteria of credibility, transferability, dependability, and confirmability that Lincoln and Guba (1985) introduced to refine the trustworthiness of research.

Credibility is achieved by being familiar with the topic and having collected sufficient data to merit the claims of the study (Eriksson & Kovalainen, 2008). In addition, to produce a credible paper, there must be a logical link between observations and conclusions derived from them (Eriksson & Kovalainen, 2008). Section 3 of this thesis introduces the research methodology and, moreover, aims to explain the reasoning and decision-making processes to appear as transparent as possible. Transferability is associated with the responsibility to show a degree of similarity between the study in question and prior studies in the field (Eriksson & Kovalainen, 2008). The transferability of the results of this thesis to other studies is apparent. This is presented in detail in Section 5 of this study. Dependability can be achieved by ensuring that the research process is logical, traceable, and well documented (Nowell et al., 2017). Because this is a Master's Thesis, a supervisor from the university has been involved in the process by observing and instructing the researcher during the whole process to strengthen its dependability. Finally, confirmability is ensured by clearly addressing that research findings are derived from the data by showing how conclusions have been made (Nowell et al., 2017). Chapter 3.3. aims to fulfil the criteria concerning the confirmability of this thesis. Moreover, throughout the whole process, the researcher has been striving to be as transparent as possible with what he is doing, why it is done, and how it is done to ensure the trustworthiness of this thesis.

While the above-mentioned measures have been taken to ensure the trustworthiness of the thesis, there are some limitations associated with the study. One of them is the rather small number of interviews. While close attention was paid to choosing suitable interviewees, who are found to be 'experts' on the subject in their field, the number of them still limits the generalization of the findings of this thesis. On the positive side, all the interviewees were from different companies, and all those companies can be regarded as major players in the chosen field. Furthermore, the interviews were conducted in Finnish because all the interviewees spoke the language fluently. While the thesis itself is done in English, this meant that interviews required translation. All the data derived from the interviews was translated by the researcher, who is not a professional translator. It is also worth noticing that despite the researcher doing everything according to his best abilities, this is still a Master's Thesis and the author's experience in conducting scientific research is limited. The last noticeable factor regarding the limitations of this thesis that may or may not affect the results is terminology. During the interviews, it was noticed that all the interviewees had a broad understanding of CE and its meaning. This was simply figured out by asking interviewees to explain in their own words how they understood CE. However, when the concept and different subjects related to it were discussed, there appeared to be slight obscurity regarding which things were understood to be associated with CE and which were not. For this reason, it is possible that something did not come up in the interviews simply because the interviewee may not have regarded it as part of CE.

6.3 Future research

CE implementation within the construction industry is still in its early stage, but interest in it is rapidly growing. However, several factors that hinder the implementation were mentioned in the prior literature and also recognized in this research. One that stood out from the research findings of this thesis was associated with the use of reused and recycled building materials. Benachio et al. (2020) even stated that the reuse of building materials is one of the biggest barriers to the adoption of the CE in the construction industry, and further research is needed to develop standard practices for the reuse of building materials. The availability of these materials was seen to be quite limited, which was expected to be because of the strict quality requirements for building materials. Several interviewees mentioned that they are researching and developing these circular materials and their use together with their suppliers. While cooperation with universities was also mentioned in the same context, more research could be done by scientific researchers.

As it has been noted throughout the thesis, the literature regarding the economic impacts of CE implementation and measurement practices associated with those impacts is still rather limited within the construction industry. While the research findings of this thesis shed some light on the economic impacts of implemented CE practices and how the economic impacts are perceived, concrete quantitative data is still non-existent, at least in public scientific literature. The benefits of this kind of data could be vast because while the aspect of environmental sustainability is central in CE, it must simultaneously be able to compete with the linear model economically. A more comprehensive understanding of the economic impacts of CE implementation could potentially speed up the transition to more holistic circularity within the construction industry. Regarding measurement practices, the results of this thesis suggest that there could be a demand for measurement practices and tools that can monitor the success of CE implementation and the economic aspects related to it.

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APPENDIX 1 Interview frame

Pre-designed interview questions (translated from Finnish)

1. **Background information**
   a. Could you briefly introduce yourself and tell me about your current job?
   b. Could you tell me about the company you work for?
   c. Could you describe your company's business model? What does it do and what kind of services or products does it produce?
   d. What are the core values of the company?
   e. What are the most central parts that ensure the success of your business?

2. **Circular economy in the company's operations**
   a. How do you understand the concept of circular economy?
   b. How is CE associated with your work position?
   c. Have any CE-related goals been mentioned in the company's written strategy/values?
      i. If yes, what kind of goals?
      ii. If not, why not? Are there any unwritten goals or plans to set goals in the future?
   d. How does the company take CE into consideration in its operations?
   e. What kind of CE-related practices have been implemented into company's operations?
      i. Practices related to supply chain management and cooperation with different stakeholders?
      ii. Practices related to procuring recycled and reused materials?
      iii. Practices related to circularity of materials and waste minimization?
      iv. Practices related to creating added value to the customer?
      v. Some other kind of CE practices?
   f. Do CE-related practices mainly associate with internal processes or are they rather related to cooperation with different stakeholders?

3. **Economic impacts of CE practices**
   a. What kind of expectations and objectives does the company have regarding implementation of CE practices and projects?
      i. Expectations and objectives related to environmental sustainability?
      ii. Expectations and objectives related to economic impacts?
      iii. Some other expectations or objectives?

b. From the company's point of view, how important are the economic impacts of implementing CE into its operations?
c. What kind of economic impacts implemented CE practices have caused in the company?
    i. Positive impacts?
    ii. Impacts associated with costs?
d. How have the economic impacts been in a short-term?
e. How are the economic impacts expected to be in a long-term?
f. Have the economic impacts of CE practices been mostly negative or positive?

4. Measurement of economic impacts

a. Are economic impacts from CE-related practices being somehow measured in the company?
    i. If yes, how?
    ii. If not, why not? Are there any plans to start measuring those impacts?
b. What kind of indicators are used for the measurement?
c. Are there any other practices in use to monitor how successful circular economy related practices have been?

5. Ending and Thank You

a. Do you have anything else to add to subjects discussed today?
b. Is there something else that we should discuss about?