Circular Business Model Patterns and their Relevance towards a more Circular Economy

A case survey of 34 circular companies

Master Thesis

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Circular Business Model Patterns and their Relevance towards a more Circular Economy

A case survey of 34 circular companies

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Executive Summary

With tackling the problems of resource depletion and waste, the currently booming topic of a circular economy (CE) comes up. This concept goes beyond the processes of reusing and recycling products and looks at the entire material and energy loops of products. It is a regenerative system in which the aim is to narrow, slow or close these loops. This can be executed through various processes with examples being remanufacturing, refurbishing and extending product life by long-lasting design. Development of the CE concept and its principles may lead to opportunities and solutions to enormous global challenges that the world experiences. However, the current economy, or linear economy, is still the status quo where products are used in a take-make-use-dispose manner. Business as usual is not an option for a sustainable future, as the world is currently using 1.5 planets to support human activities. To make a transition to a more circular economy, governments, non-profit organizations, academia, research centers and also companies worldwide need to work together to establish this.

It is time for businesses to become part of the CE by designing circular business models (CBMs). Besides that the world is changing and is in need of practical solutions, also consumers become more aware of sustainability and circularity. CBMs differ from linear business models (LBMs). Differences include changes in the value chain and product design to support reparability, durability and upgradability. Moreover, in CBMs relationships with partners, suppliers and customers become more integrated. Additionally, new cost structures and revenue models should be designed. This thesis looks at patterns in circular business models (CBMPs) in scientific literature and identifies them in business practice. CBMPs are building blocks of CBMs and are considered powerful and useful tools for business model innovation (BMI). Patterns can be used as a source of information to describe and understand logics of new, unknown markets. With the arrival of the CE there are not necessarily new markets, but existing business models in many markets are changing. Knowledge of CBMPs is therefore required.

The identified gap in literature is the aim to create a more comprehensive list of CBMPs. The main research question derived from this gap is formulated as follows: Which patterns in circular business models can be identified and what are implications for these patterns for companies and the circular economy?

In the literature review the state-of-the-art regarding business models, BMPs, CE, CBMs and CBMPs is given. The most important outcomes of this study are a list of 26 CBMs, 18 barriers for implementation of CBMs and 11 CBMPs. After the literature study the founded variables are

researched in business practice using a case survey. This is a form of meta-analysis where multiple single case studies are combined. 34 companies are selected and based on information resources online and in scientific literature, these are analyzed on their CBMs, limitations and CBMPs. Hierarchical clustering analysis and chi-square tests in SPSS are used to find relations between certain CBMs and implementation barriers with CBMPs. Two semi-structured interviews are held to discuss the case survey findings and to elaborate on the contribution of CBMPs for a transition to a more circular economy.

In the case survey additional patterns defined as 'Circular solution' and 'Reverse logistics' are found and combined with the patterns in literature form the following list of 13 CBMPs: Access and performance model, adopt a stewardship role, cascading and repurposing, circular solution, industrial symbiosis, maximize material and energy efficiency, organic feedstock, recycling, refurbishment and remanufacturing, repair and maintenance, reuse and redistribution, reverse logistics and substitute with renewable and natural processes. 18 barriers of CBM implementation are identified in literature and the case survey adds another barrier to that.

Managers of companies that that need to implement circular principles and activities can, with help of CBMPs, generate new business models systematically or adapt existing business models. Study shows that BMPs are important tools for BMI as 90% of BMI cases consist of a recombination of existing BMPs. Patterns can be used again and are sources of information. Furthermore, BMPs help to describe and understand the logics of new, unknown markets. The industries where the companies in this research operate in are not new, but with the arrival of CE much in business processes needs to change. CBMPs help overcome barriers in the BMI process, which is of high importance in times of transformative change.

The work of this thesis is relevant for the transition to a CE. It is argued that more knowledge of CBMs, its patterns and its implementation barriers can enhance the CE transition. CE cannot be established with one single company or one single country alone. For CE to happen, many changes are needed and currently the principle of CE are not widely adopted. With the arrival of CE companies and their business models need to change. CBMPs can help the BMI process by giving the process the right direction. Therefore this study forms a small part and addition of and to the transition to a CE.

Keywords: circular economy, business models, circular business models, circular business model patterns, case survey

Preface

In September 2016 I came to Delft to start the master program Management of Technology. After an interesting first year and a semester abroad at the TU Munich this thesis is the last step in my studies. I would like to express my gratitude towards the key players in this final process.

First and foremost, I would like to thank my committee. My first supervisor Jaco Quist introduced me to the research topics in the circular economy. Especially in the beginning I encountered some difficulties defining my scope and objective and had troubles with finding the right methodologies. Jaco was always very helpful giving me directions to form a proposal that suited me best. My second supervisor Mark de Reuver helped me further in my research approach and provided structured and valuable feedback. Both supervisors possess a lot of knowledge and it showed me that they excel in their profession.

Secondly, I would like to thank the case authors and the interviewees for their contribution to my work. It was interesting to hear about their view on certain topics and to discuss my findings. They all share strong curiosity and passion for the circular economy, which is enervating to see.

Lastly, I would like to thank my friends and family. As cheesy as it may sound, I am not sure if I would have made it without them. To the ones whom I have known my whole life to people I only met in the last few years: I am amazed and grateful to have so many supportive and inspiring people in my life! They bring out the best of me.

L.J. Huitema

Leiden, December 2018

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Abbreviations

BMI	Business model innovation
BMP	Business model pattern
CBM	Circular business model
CBMP	Circular business model pattern
CE	Circular economy
LBM	Linear business model

Chapter 1 | Introduction

This chapter introduces the research topic of this thesis. It gives background information (Section 1.1) and elaborates on the motivation and relevance of the topic (Section 1.2). The relevance is divided into three parts: the relevance of this topic regarding scientific research; the social relevance and the relevance to the study program Management of Technology at the Technical University of Delft. Afterwards, the knowledge gap (Section 1.3) and the corresponding research questions are presented (Section 1.4). For each sub research question the methodology is shortly introduced. Next, in Section 1.5, the research approach is presented. This chapter ends with a reader's guide and a visualization of the project in a research flow diagram, in which it becomes clear how the research questions and chapters are structured together (Section 1.6).

1.1 | Background

Issues as pollution and global warming are serious worldwide problems. Deforestation, increase in toxic pollutants and loss of biodiversity are just some of the trends that Speth (2008) mentions that have been present in the last few decades. To stop these trends before it is too late, radical changes are needed. Economic and technological development have established our modern society but are also big causes of natural resource depletion and waste. The Earth Overshoot Day, which marks the point in the year at which consumption exceeds the capacity of nature to regenerate, fell on the 1st of August in 2018. This is the earliest ever recorded date, and study says that this date will arrive earlier every year (The Guardian, 2018). Rethinking and changing the ways the economy is working is therefore required.

With tackling the problems of resource depletion and waste, the currently booming concept of a circular economy (CE) comes up. It concerns more than 'just' the recycling or reuse of products. CE is "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Geißdörfer et al., 2017, p. 759). Besides processes such as recycling and reusing of products, the definition of CE goes further and also focuses on extending product life cycles and minimizing waste by closing resource loops. By slowing, closing and narrowing material and energy loops, the development of CE can lead to opportunities and solutions to enormous global challenges such as resource depletion, the food problem, the waste surplus and climate change. The era of the linear economy or take-make-waste approach, is not yet over. It still "constitutes the status quo in most manufacturing industries, barring some limited use of recycled materials

and remanufacturing of spare parts" (Linder & Williander, 2017, p. 184). To make a transition from the current linear economy to a circular one, governments, non-profit organizations, academia, research centers and companies all over the globe need to work together. If the transition to a CE succeeds, it may even be seen as the next industrial revolution (Ewen et al., 2017). Apart from changes that are needed in policies, laws and regulations, also businesses need to reform their way of thinking by designing circular business models (CBMs) in order to make use of the innovative possibilities that the CE brings. Linder & Williander (2017, p. 183) define a CBM as "a business model in which the conceptual logic for value creation is based on utilizing economic value retained in products after use in the production of new offerings". Furthermore, business model and design strategies need to go hand in hand in the transformation from a linear economy to a CE (Bocken et al., 2016). An example of a circular company is the carpet manufacturer Interface. The company produces modular carpet for commercial and residential applications and states it is committed to CE and sustainability in its Climate Take Back project (Interface, 2018).

Even though that the concept of CE sounds as a highly suitable approach to e.g. resource depletion, there is still reluctance in implementing CBMs into businesses due to various challenges and limitations that increase risk. An example is a cultural barrier, because the fear of the unknown from individuals and organizations hampers CBM implementation (Oghazi & Mostaghel, 2018). Another limitation is that a CBM always has a higher risk than a linear business model (LBM) (Linder & Williander, 2017). A different problem that was found is the lack of a clear problem owner: no one is going to act when they do not take the full responsibility to overcome the (big, world-wide) problem (Roos, 2014). There has been a constant discussion about which countries, organizations or other institutions should take the responsibility to become the problem owner (and solver) of e.g. the temperature increase on earth.

This research further explores the field of CE by investigating its business models and business model patterns (BMPs) in existing circular and sustainable companies in different countries. BMPs are patterns that have been observed in multiple business models and can be a powerful tool for business model innovation (BMI). Circular companies are companies focused on a CE principle, such as extending the product value and the use of circular supplies. The aim of this research is to explore and investigate the circular business model patterns (CBMPs) by looking at CBMs and CE-related barriers of implementation.

1.2 | Motivation and Relevance

In the background section it became clear that due to global, serious issues the topic and practices of CE need to be explored rapidly. This can determine if CE is able offer innovative solutions to those problems in a successful way. When research into this topic continues, CE will be a growing and emerging social-economic paradigm (Merli et al., 2018). This section explains the motivation and the relevance of the topic from three views: scientific, social and study program relevance.

1.2.1 | Scientific Relevance

Merli et al. (2018) stated that more attention should be devoted to CE in academic research. This research aims to broaden the existing knowledge on circular business model patterns (CBMPs) in companies. After completion of this research this can be studied further. Another relevance point is that existing BMP databases could be expanded if new patterns are found. Findings of this research could form a contribution to the knowledge base on CE and CBMs in scientific literature.

1.2.2 | Social Relevance

Findings of this research might provide a contribution to the public. Existing companies that want to implement CE into their business or entrepreneurs who want to set-up a new business involved in CE can use and learn from the results of this thesis for their own use. Besides, governments can make use of this research to find out how they can help regarding changing policies, legislation and regulations in order to create a more circular economy. The conclusions of this research might create new insights to both industry and governments. This will help both actor segments in their contribution to the CE principles. Eventually, this will lead to the fact that next generations continue to have the access to the same resources as we have today. That this is necessary, was put forward by Bocken et al. (2014) by stating that business as usual is not an option for a sustainable future, as the world is currently using 1.5 planets to support human activities.

1.2.3 | Relevance to the Study Program

Three main criteria were established as indicators of a suitable thesis project for the master program Management of Technology. These criteria were defined as follows:

1. *"The work reports on a scientific study in a technological context"*
   Later in this introduction chapter it will become clear that an extensive literature study will be conducted to elaborate on the state-of-the-art regarding CE and to find an overview of identified CBMPs. Most of the companies that will be studied in this research are involved with innovative high technology. These new technologies are used for their CE practices and processes, and are incorporated in their business model.

2. *"The work shows an understanding of technology as a corporate resource or is done from a corporate perspective"*

   The point of view in this thesis is from the (circular) company. CE is a booming topic that might change the current economy as we know it. It is therefore crucial for companies to anticipate. This research will show that CE principles requires technological expertise and has to be incorporated in the business models of companies. Innovative high technology involving CE can support the company in its survival in the current era.
3. *"Students use scientific methods and techniques to analyze a problem as put forward in the Management of Technology curriculum"*

   The broad curriculum of the study will be used throughout this research. Courses that were used for its information and methods in this thesis are MOT1533 High-Tech Marketing, MOT1435 Technology, Strategy & Entrepreneurship, MOT2312 Research Methods and MOT1451 Inter- and Intra-Organizational Decision-Making.

The topic of this research applies to the three criteria and therefore, this research ought to be a suitable master thesis.

1.3 | Knowledge Gap

As noted before, the CE is an upcoming and booming topic. Merli et al. (2018) found that in 2004 only one paper on CE was published, but that this number grew exponentially to 215 publications in 2016. However, the scholars conclude that the academic debate on CE is still insufficient, and more investigation, especially regarding rethinking and reshaping new approaches to production and consumption, is needed (Merli et al., 2018). This thesis aims to combine knowledge of BMPs with circularity. Lüdeke-Freund et al. (2018) developed six major CBMPs, but states that their approach is not complete and that e.g. behavioral aspects are not covered. An example of a behavioral aspect is the promotion of sufficient lifestyles. A database of 182 patterns was established by Remane et al. (2017). Their objective was to make the knowledge on BMPs more accessible for both practical application as well as theoretic enhancements of the concepts. However, this database does not focus on patterns related to circularity. The identified gap in literature is the lack of a comprehensive list of CBMPs. This thesis aims to create a more complete list of patterns and will investigate what value these patterns can have for circular companies.

1.4 | Objective and Research Questions

As noted before, this thesis aims to create a more complete list of patterns and will investigate what value these patterns can have for circular companies. Since (C)BMPs are considered powerful tools for BMI and rethinking business models is part of a CE, it is expected that

knowledge is important and needed. Now, the research objective, the main research question and the four sub research questions are presented. Afterwards the sub research questions will be elaborated on further with an introduction on which methods will be used to answer them.

The objective of this thesis is: *To identify which circular business model patterns exist and what their relation is to circular business models and implementation barriers that circular companies experience. Besides, to investigate what implications circular business model patterns have for companies and how they are placed in the transition from a linear to a more circular economy.*

The main research question is: *Which patterns in circular business models can be identified and what are implications for these patterns for companies and the circular economy?*

The main research question is divided into four sub research questions. These questions are:
1. What are the main developments on circular business models in scientific literature and the barriers in implementing them for companies?
2. What are circular business model patterns and which patterns are identified in scientific literature?
3. Which circular business models, circular business model patterns and implementation barriers can be identified in business practice?
4. How can circular business model patterns stimulate more widely adoption of circular business models and how can this contribute to a transition to a more circular economy?

1.4.1 | Main Developments in CBM Literature and Implementation Barriers

The first sub question is: *What are the main developments on circular business models in scientific literature and the barriers in implementing them for companies?* This question will be answered in a literature study. The latest articles and findings on CBMs will be studied and a common understanding for the difference between linear and circular business models will be established. The second part of this question focuses on implementation barriers that companies experience when implementing a CBM. An as-complete-as-possible list of problems, challenges and limitations will be created. This question is important in this research, because it will be studied if certain business model patterns are correlated to certain problems. As the linear economy is still the status quo, it can be helpful to study implementation barriers. These insights can be important for actors trying to lower the barriers that exist.

1.4.2 | Circular Business Model Patterns

The second sub question is: *What are circular business model patterns and which patterns are identified in scientific literature?* First, a definition of a CBMP will be presented. Afterwards, review, database and pattern discovery papers will be researched in order to find or form a list of currently identified CBMPs. The question aims to find an answer that has an as-complete-as-possible list of patterns. The focus will lie on CBPMs, meaning the patterns that are specifically seen in companies that operate circular or have sustainability values high at stake.

1.4.3 | Applicability to Business Practice

The third sub question is: *Which circular business models, circular business model patterns and implementation barriers can be identified in business practice?* The bulk of this research will be executed to answer this question. For this, the case survey methodology will be used. Yin & Heald (1975) were one of the first to mention and apply this research method that fits studies with a heterogenous collection of case studies. Case survey is a meta-analysis, which is a statistical analysis that combines the results of multiple case studies. The unit of analysis in the cases is the organization. A single case study generally generates much in-depth information about a company. A downside of this is that the results of such a study cannot be generalized to other organizations. In a case survey the results of single case studies, which are primarily qualitative, are coded to quantitative data so that (statistical) analysis can be conducted. Therefore, the case survey methodology combines two fields of research, namely the quantitative analysis of a few variables across large samples and the qualitative, multi-aspect, in-depth study of one or a few cases (Larsson, 1993). The coding translates the original data with help of closed-end questions. In this way, single case studies combined can be used to generalize conclusions and look at cross-sectional patterns. Jurisch et al. (2013) provided a visualization of the case survey methodology in five stages. The same stages will be used in this research and a protocol will be made. The protocol lists all the factors that are going to be coded as well as the operationalization that shows how to do that. This ensures that replicability of the study is possible, which is one of the eight hallmarks of scientific research according to Sekaran & Bougie (2010). Hierarchical cluster analysis and chi-square tests will also be used for this sub research question to see if and how the variables are related and a case author will be asked to comment on the case survey findings. This last point is executed to increase reliability of the results.

1.4.4 | Contribution to a More Circular Economy

The fourth sub question is: *How can circular business model patterns stimulate more widely adoption of circular business models and how can this contribute to a transition to a more circular economy?* This part of the research is answered with conducting semi-structured interviews with

two academic researchers in the field of CE. The experts can provide more knowledge or insights from the results of the case survey study. They will be asked what is needed for a more circular economy than we experience now and during this interviews it will be discussed how CBMPs are placed in the transition and what possible implications are for companies.

1.5 | Research Approach

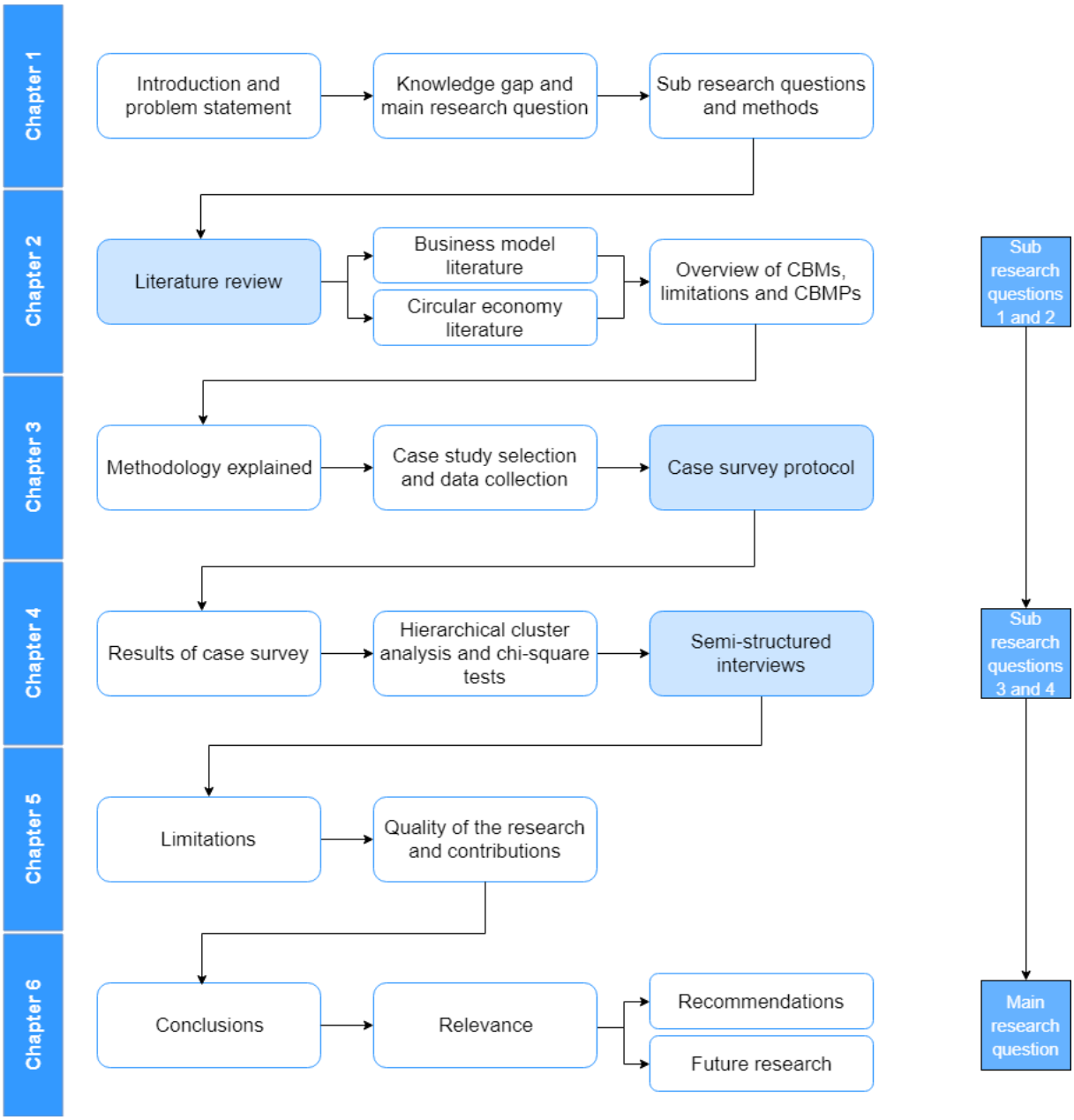
This research will be descriptive. The main research approach used in this thesis is the exploratory approach. According to Sekaran & Bougie (2016, p. 43), explanatory research questions "are typically developed when: a) not much is known about a particular phenomenon; b) existing research results are unclear or suffer from serious limitations; c) the topic is highly complex; or d) there is not enough theory available to guide the development of a theoretical framework". This is the situation for the research topic that has been described for reasons a) and c). Currently, not much is known about CBMPs in scientific literature. Besides, the topic is highly complex and many factors play a role in CBMs. Advantages of this approach are the flexibility and the adaptability to change. A drawback of this approach is that it can be subject to bias since it generates qualitative information and interpretation. However, a more quantitative method is going to be used in this research for the third research question, which will try to counter this argument.

1.6 | Reader's Guide

The structure of this thesis is as follows: Chapter 2 contains the literature review on BMPs and CE and will answer the first two sub research questions. It introduces and explains the concepts, gives a state-of-the-art of related literature and ends with naming the most important findings and explaining how these findings will contribute to the rest of the research. In Chapter 3 the case survey method and the semi-structured interview are introduced, explained and discussed. The chapter presents how the coding scheme was designed and how the data collection took place. It will provide a short introduction on how the data will be analyzed. This chapter also contains the circular companies that were found and selects those companies that will be used for the research. Chapter 4 explains the generic results of the case survey and will investigate cluster analysis and chi-square tests in a statistical program. The chapter provides the answers for the third and fourth sub research question. Chapter 5 is the discussion chapter and will elaborate on what the results actually mean and presents different types of limitations. The final chapter, Chapter 6, gives the reader the answer to the main research question, elaborates on the relevance of the study, provides recommendations to different actors and possibilities for future research.

This ends the introduction chapter of this thesis. In Figure 1, a visualization of the thesis is shown. It is an overview of the project. The far-left column represents the corresponding chapter in the thesis, the light blue colored boxes are the methods that are going to be used and the blue boxes on the far-right present where the (sub) research question is answered. With arrows the steps in the thesis are chronologically visualized.

Figure 1. Visualization of the project



Chapter 2 | Literature Review

In this chapter the scientific literature regarding the main topics of this research are going to be addressed. The results of this literature review provide the answer for the first two sub research questions and form the basis for the case survey method and the semi-structured interviews that will answer the third and fourth sub research question in Chapter 3 and 4. The structure of this chapter is as follows. First, Section 2.1 proposes the approach to the literature study. Second, business models and BMI are addressed (Section 2.2). Section 2.3 provides the reader an overview on BMP literature including a taxonomy that was designed. Fourthly, CE and CBMs are investigated in Section 2.4. Fifthly, the implementation issues of CE principles into the current economy are analyzed (Section 2.5). Section 2.6 addresses the CBMPs, Section 2.7 presents the main findings of the literature review and the last section answers the sub research questions (Section 2.8).

2.1 | Approach Literature Study

A step-by-step approach is followed to go through the literature. First, (academic) papers are going to be searched using the following key words:

- Business model
- Business model innovation
- Business model pattern
- Business model pattern database/review
- Circular economy
- Circular business model
- Circular business model pattern
- Business models for circular economy
- Business models for circularity

Online journal databases such as theses repositories, Scopus, Google Scholar and Science Direct are going to be consulted for this. The found papers are scanned and read in order to create an overview of identified CBMPs. Besides academic literature, also grey literature will be conducted to find the state-of-the-art of all topics. As an example, current governmental and European Union approach to CE will be studied.

2.2 | Business Models and Business Model Innovation

Business models have been widely studied in various disciplines, such as management, economics, strategic management and marketing (Gatautis, 2017). The business model helps to look at the core processes of the firm, "looks at the forest, not the trees" and is used as a lens for understanding a company's underlying logic (Remane et al., 2017). A literature review by Shafer et al. (2005) combined and analyzed twelve papers on business model definitions and concluded with the following composite definition for the business model: "a representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network" (Shafer et al., 2005, p. 202). The term has been around for decades and "describes the rationale of how an organization creates, delivers and captures value" (Osterwalder & Pigneur, 2010, p. 23). Both definitions include the same dimensions of strategic choices, the value network, creating value and capturing value. These dimensions can be found in other definitions of business models as well, although sometimes they are formulated or named differently. Boons & Lüdeke-Freund (2013) distinguished these components of a business model and explain them in the following way:

1. *Value proposition* – what value is embedded in the product/service offered by the firm;
2. *Supply chain* – how are upstream relationships with suppliers structured and managed;
3. *Customer interface* – how are downstream relationships with customers structured and managed;
4. *Financial model* – costs and benefits from 1), 2) and 3) and their distribution across business model stakeholders (Boons & Lüdeke-Freund, 2013).

Other definitions divide the definition of a business model in three dimensions, namely value proposition, value creation and value capture (Oghazi & Mostaghel, 2018). The value proposition means the value that is provided and to whom, the value creation (and delivery) entails how the value is provided and delivered, and value capture is about how the company makes money out of the created value; thus, the revenue model.

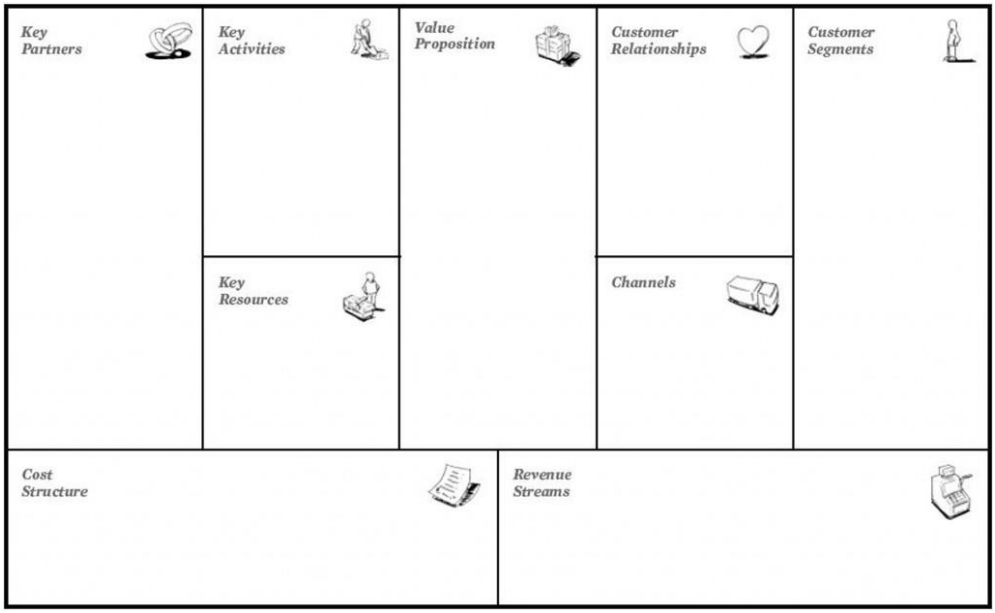
The definition that is going to be used throughout this thesis is the one of Osterwalder & Pigneur (2010). It is a frequently used definition in literature and explains in simple words its meaning. To recall, the business model "describes the rationale of how an organization creates, delivers and captures value" (Osterwalder & Pigneur, 2010, p. 23).

2.2.1 | Business Model Innovation and Tools

The concept business model innovation (BMI) comes up when a firm redesigns its existing business model or creates a new business model. In a fast-changing world with the rapid development of new, emerging technologies and dynamic markets, BMI became important for the firm in order to survive in its industry (Gatautis, 2017). Defined by Bocken et al. (2014), BMI "offers a potential approach to deliver the required change through re-conceptualizing the purpose of the firm and the value creating logic, and rethinking perceptions of value" (Bocken et al., 2014, p. 43). A literature review by Boons & Lüdeke-Freund (2013) showed that BMI is a presiding subject in the literature on business models as an important aspect of creating competitive advantage and renewing organizations. Furthermore, the relevance and need for BMI has increased over the last decades. This was put forward by Roos (2014, p. 248), as the author saw "increasing relevance of BMI in domains such as airlines where new business models have increased their share fivefold over the last 30 years". When a firm chooses a particular business model, it means that the firm chooses a particular way to compete (Casadesus-Masanell & Ricart, 2010). The process of BMI has been divided by Osterwalder & Pigneur (2010) into the following five phases: mobilize, understand, design, implement and manage.

To establish a business model or engage in BMI, various BMI tools exist that work as a guide for firms to define their business model. A well-known example of such a tool is the business model canvas created by Osterwalder & Pigneur (2010). It is a strategic management template and consists of nine building blocks, which are divided into the categories of value creation, value proposition, value capture and value delivery. In the category of value creation the building blocks key activities, key resources and key partners are located. Customer segments, channels and customer relationships belong to the value delivery category. In value capture the cost structures and revenue streams are put. The visualization of the model is shown in Figure 2, this template is a practical tool for companies. Other examples of BMI tools or ontologies are the STOF model (Bouwman et al., 2008), VISOR (Pereira & El Sawy, 2013) and BMPs. The last tool is going to be used in this research and going to elaborated on further in the next section.

Figure 2. Business model canvas (Osterwalder & Pigneur, 2010)



2.3 | Business Model Patterns

Another tool for BMI is the business model pattern (BMP). When scholars explain this term, some of them go back to the definition of a pattern by Alexander et al. (1977). Alexander et al. (1977, p. 17) uses the following definition for a pattern: "Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice". An example of scholars using this definition as a starting point to understand and explain BMPs is the paper of Remane et al. (2017). The authors found in the Alexander et al. (1977) definition of a pattern three aspects that are also considered important for patterns in business models. These three aspects are:

1. Alexander et al. (1977) states that patterns are used to describe a "solution" to a recurring "problem" that needs to be solved. An example of a reoccurring problem in a BMP view is that a business model has to capture value, where a pricing strategy such as a 'flat-rate' can function as a solution to that problem;
2. Patterns describe "the core of the solution", for BMPs this means that a pattern often describes a solution for only a specific part of a company's business model. This is the reason why complete business models of firms are often a combination of several patterns (Osterwalder & Pigneur, 2010);
3. A pattern should be usable "a million times over" and therefore requires a certain level of generalization. This is also the case regarding BMPs, it is only considered a pattern when it has been used multiple times (Remane et al., 2017).

The beforementioned three aspects are used in the definition of BMPs in several academic papers (Remane et al., 2017). One definition is proposed by Osterwalder & Pigneur (2010, p. 55). The authors describe BMPs as "business models with similar arrangements of business model Building Blocks, or similar behaviors". Echterfeld et al. (2015, p. 320) define a BMP as "a combination of configuration options, which repeatedly occurs in successful business models". For a research involving BMI, BMPs are described as "a theoretical construct in management literature that offer granular unit of analysis in the context of business models with a multipurpose role, such as classification device, instrument of scientific inquiry or recipe and can be characterized with the notion of ideal types" (Salehar, 2017, p. 46). The definition of BMPs that will be used throughout this thesis is the one of Osterwalder & Pigneur (2010) mentioned in this paragraph.

Some examples of BMPs that literature gives, are:

- *"Cool brands" or brand building* – through expert brand marketing, a company can ask premium prices with competitive products. An example of such a company is Nike (Remane et al., 2017);
- *Flat-rate* – this occurs when a firm charges a monthly, fixed price and allows the customer unlimited access in exchange. A well-known example here is the media service provider Netflix (Gassmann et al., 2014);
- *Open source (alliance)* – the product here is not developed only within a company, but the public community helps developing with all information being available publicly. Examples are Linux and Wikipedia (Gassmann et al., 2014).

The book by Gassmann et al. (2014) included an extensive empirical research of BMI cases in the last 50 years. In these cases, 55 core BMPs were identified. These patterns were seen in an applied form, a combination form or a re-application form. This means that the pattern was used in the exact same way or a small adaption was made. The importance of BMPs is underlined with that more than 90% of these BMI cases consisted of a recombination of existing BMPs. Furthermore, in most cases BMI was successful with only a limited number of patterns. This finding proves that BMPs can be viewed as an important powerful BMI tool. Since patterns can be used again, this can be used as a source of information for (new) companies that want to become viable, profitable and in this research context, circular and sustainable. Echterfeld et al. (2015) adds to that finding, in their research the authors found that BMPs are a valuable approach to describe and understand business logics of new, unknown markets.

The main topic of research for Remane et al. (2017), who were earlier mentioned for the definition of BMPs, is the meta-analysis on BMP reviews and collections. Their aim was to create an as-

complete-as-possible BMP database, with the underlying reason that BMPs are strong tools for BMI. BMPs do not focus on imitating, but rather address efficiency, spur creativity and help to overcome cognitive barriers in the BMI process, which is of importance in times of transformative change (Chesbrough, 2010). The BMP taxonomy that was created by Remane et al. (2017) is explained in the next section.

2.3.1 | Business Model Patterns Taxonomy

The established BMP database by Remane et al. (2017) consists of 182 unique patterns. The authors found and used 22 original articles as well as six reviews on BMPs. They tried to face two shortcomings that they found in existing literature. These shortcomings were firstly, that no list was exhaustive, and secondly, that duplicates existed. Remane et al. (2017) created a taxonomy to describe these 182 patterns. They created twelve dimensions in five different categories. The categories (value proposition, value delivery, value creation, value capture and 'overarching') are similar to the four frequently found categories in business model definitions (See Section 2.2). The adapted dimensions, their characteristics and number of patterns per characteristics can be found in Table 1. Each row adds up to 182 patterns.

Table 1. Taxonomy retrieved from Remane et al. (2017, p. 22)

	Dimension	Characteristic						
Overarching	1: Hierarchical impact	Prototypical pattern (87)	Solution pattern (95)					
	2: Degree of digitalization	Purely digital (55)	Digitally enabled (35)	Not necessarily digital (92)				
Value proposition	3: Product type	Physical (12)	Financial (7)	Human (5)	Intellectual property (36)	Hybrid (10)	Product type not specified (112)	
	4: Strategy for differentiation	Quality (9)	Customization (8)	Combination (13)	Access/ convenience (6)	Price (22)	Network effect (11)	No impact on differentiation (113)
Value delivery	5: Target customers	Specific new customer segment (10)	Lock-in existing customers (9)	Other companies (B2B) (7)	No impact on target customers (156)			
	6: Value-delivery process	Brand and marketing (7)	Sales channel (20)	Sales model (9)	Customer relationship management (3)	No impact on delivery process (143)		
Value creation	7: Sourcing	Make (17)	Buy (11)	No impact on sourcing (154)				
	8: Third parties involved	Suppliers (9)	Customers (12)	Competitors (3)	Multiple parties (18)	No impact on third parties involved (140)		
	9: Value-creation process	Research and design (7)	Supply (5)	Production (8)	Multiple steps (11)	No impact on creation process (151)		

Value capture	10: Revenue model	Sell (15)	Lend (20)	Intermediate (18)	Advertising (12)	No impact on revenue model (117)			
	11: Pricing strategy	Premium (11)	Cheap (9)	Dynamic (12)	Non-transparent (8)	No impact on pricing strategy (142)			
	12: Direct profit effect	Increase revenue (42)		Reduce cost (15)	Multiple effects (11)	No direct profit impact (114)			

The twelve identified dimensions in the second column are organized into five categories, seen in the first column. Four of those categories are found in the definitions of a business model (Shafer et al., 2005; Osterwalder & Pigneur, 2010). The components value proposition, value delivery, value creation and value capture also form the inputs of the business model canvas, which is the BMI tool founded by Osterwalder & Pigneur (2010). The other category of dimensions is called 'overarching', which means that these dimensions are a combination of multiple business model components. The twelve dimensions consist of several characteristics and every identified BMP can be placed in one of these characteristics; in other words, every row adds up to 182. The first dimension consists of only two characteristics, whereas the fourth dimensions has seven characteristics.

Now, one of the identified BMPs is going to be described using the table. The chosen pattern is 'content-targeted advertising', which entails identifying the meaning of a web page and then automatically deliver relevant advertisements when a user visits that page. This is a pattern used by the company Google. The pattern does not have impact on all dimensions mentioned in Table 1, but it does on the following: 1, 2, 4 and 10. The first dimension, the overarching hierarchical impact describes a prototypical business model or a solution pattern. Prototypical patterns describe the general set-up of a company's business model, whereas solution patterns imply actions to change only sub-aspects of it. For Google, the content-targeted advertising is a solution pattern. The second dimension is degree of digitalization (second dimension), for Google this is purely digital. The strategy for differentiation (fourth dimension) that Google takes with this pattern is customization, because advertisements are only given to specific customer target segments. The revenue model (tenth dimension) for this pattern is advertising. The other 181 BMPs can be described in the same way using Table 1.

Ng (2017) categorized BMPs in six base categories, namely preparation, positioning, product & service logic, value creation logic, sales & marketing logic and profit formula. For this taxonomy, Matzler's BMI Logic and the business model building blocks from Osterwalder & Pigneur (2010) were used. When the model was finished, it was validated by mapping out five firms across five industries. Two interesting observations were observed, namely first, businesses do not necessarily innovate in all categories at the same time, and second, some firms may adopt more

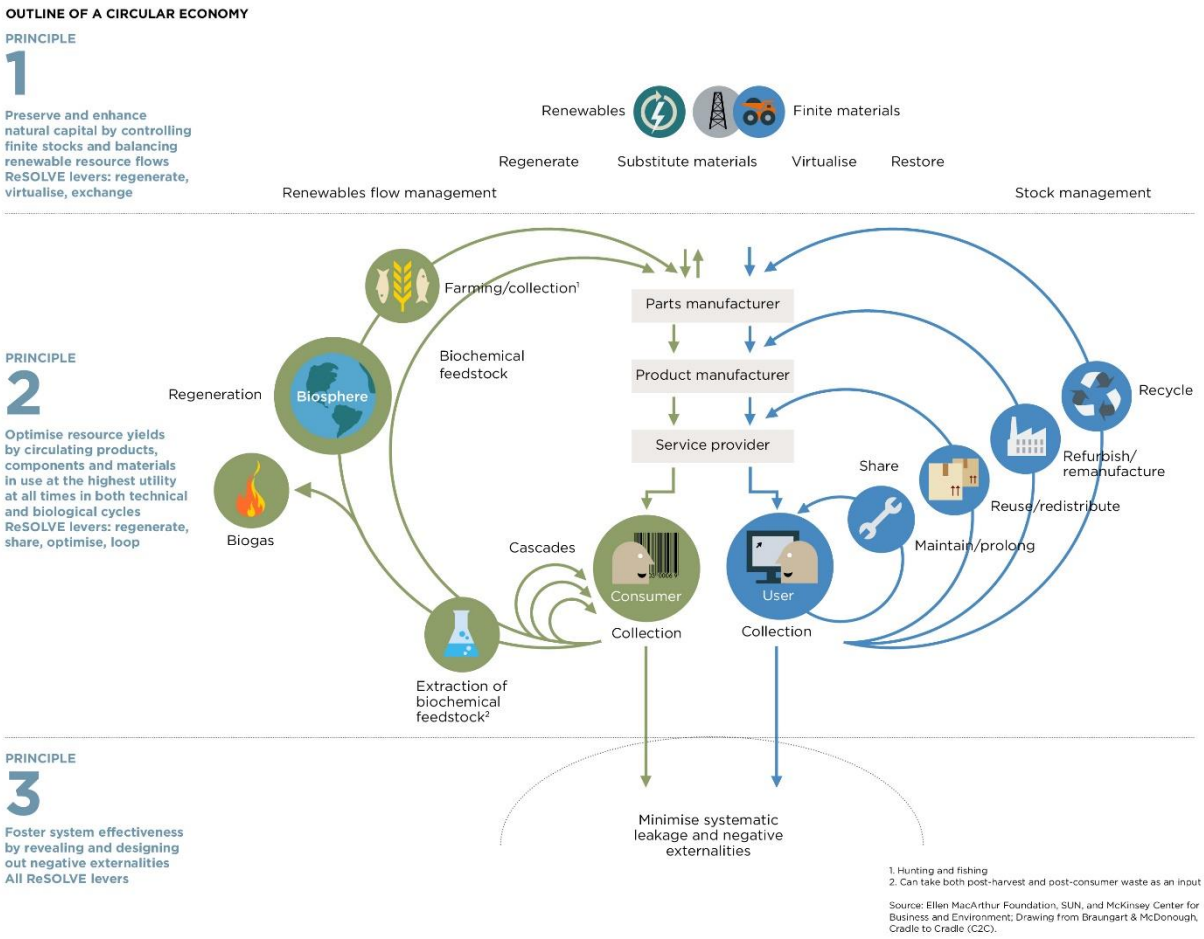
than one type of BMP for a single base category. This also confirms the findings of Osterwalder & Pigneur (2010) and Remane et al. (2017) that complete business models consists of multiple BMPs.

The first part of the literature review provided the definitions and explanations of generic business model concepts such as BMI and BMP. Now, the circular economy and its business models are elaborated on in the next sections.

2.4 | Circular Economy and Circular Business Models

In a CE, resources are circularized. It "refers to an industrial economy that is restorative by intention; aims to rely on renewable energy, minimizes, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design" (EMF, 2013, p. 22). This means that materials that are used in the production of a product are in a way re-used or recycled and thus, per definition, no waste is generated in the process. A thorough definition of CE was proposed as follows: "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Geißdörfer et al., 2017, p. 759). This definition incorporates besides material loops also energy loops. An example of closing an energy loop is the use of excessive heat that was left in a certain production process in a different heating process. The energy is not wasted and this transfer is possible within a company, but can also exist between different companies that have production areas close to each other to transport the excessive heat. This is a part of industrial symbiosis. The definition of CE makes another distinction in loops, namely slowing, closing and narrowing loops. Closing a resource loop implies that no waste is generated, whereas slowing a loop focuses on e.g. extending the life of a product. Bocken et al. (2016) summarize the difference between slowing and closing loops as follows: "slowing is about prolonged use and reuse of goods over time, through design of long life goods and product life extension, whereas closing loops is about reuse of materials through recycling" (Bocken et al., 2016, p. 310). The third category of changing a material or energy loop, which is the narrowing of a loop, is defined as resource efficiency, aiming at using fewer resources per product (Bocken et al., 2016). This can also be realized in a linear economy. An overview of the outline of a CE by EMF (2012) is shown in Figure 3.

Figure 3. Outline of a circular economy retrieved from EMF (2012)



The outline of CE includes three principles, as seen in the image above. The first principle is about the transition to renewable energy. The second principle is about the optimization of both technical and biological resource loops. The core of the third principle is to get rid of negative externalities. For this research, the second principle is the focus since that is where the companies with a CBM operate in. The unit of analysis of the research is the circular company. The outline was created by the Ellen MacArthur foundation. This foundation was founded in 2010 with the goal to promote the transition from a linear economy to a circular one. The foundation is concerned with different circular related topics, such as learning, business and government, insight and analysis, systemic initiatives and communications. The image illustrates that different processes are used in a CE, such as sharing, maintaining and prolonging, reusing and redistributing, refurbishing and remanufacturing and recycling. An example of a company focused on remanufacturing is Refuse Vehicle Solutions, that is based in the United Kingdom, and remanufactures vehicles to extend the life cycle of its product (Refuse Vehicle Solutions, 2018).

The direct opposite of CE is the current linear economy. The era of the linear economy or take-make-waste approach is not yet over, it still "constitutes the status quo in most manufacturing industries, barring some limited use of recycled materials and remanufacturing of spare parts" (Linder & Williander, 2017, p. 184). However, business as usual is not an option for a sustainable future, because the world is currently using 1.5 planets to support human activities (Bocken et al., 2014). Implementation of CE in the near future may lead to opportunities and solutions to enormous global challenges, such as resource depletion, the food problem, the waste surplus and climate change. Therefore, it is important that the transition starts now or very soon. If the transition to a CE succeeds, it may even be seen as the next industrial revolution (Ewen et al., 2017).

2.4.1 | Taken Actions in the Implementation of CE Principles

There are two ways to implement CE, the first one is top-down with the help of policies and legislation, and the second one is bottom-up with firm competitiveness and profitability (Oghazi & Mostaghel, 2018). It is important that all actors (thus the government, firms, research institutes, universities, etc.) are aligned and are active in the implementation process. In the view of Oghazi & Mostaghel (2018), in the long term the industry has to transit towards CE in order to survive. This is mainly because of resource depletion, in the long-term resources may run out.

According to scholars, the first country that acted regarding the implementation of CE was China. It was first proposed by scholars and then accepted in 2002 as a new development strategy by the government. The objective of the Chinese government is to promote the sustainable development of the economy and society. At the same time, it tries to gain sustainable environmental protection (Yuan et al., 2008). An example of a measure from China is the "Cleaner Production Promotion Law", which was put into effect in January 2003.

The Dutch government has been active with CE for a long time. A recent CE project was launched in September 2016. The deadline they put on the finishing of the transition is the year 2050, for the same reasons that were mentioned by Oghazi & Mostaghel (2018). The responsibility of this government-wide project lies with the Ministry of Infrastructure and Water Management and the Ministry of Economic Affairs and Climate Policy. The government takes several measures that aim to encourage the transition, these measures include:

- Fostering legislation and regulations;
- Intelligent market incentives;
- Financing;

- Knowledge and innovation;
- International cooperation (Government.nl, 2018).

These measures can be very effective for companies. Legislation and regulation can both encourage and hamper innovation. An example that the Dutch government names here, is by making sharing cars or other tools easier as to promote a sharing economy (Government.nl, 2018). To force governmental organizations to only buy circular products – which are products that can be reused – is an example of an intelligent market incentive. The government also focuses on financing, because investing in circular companies has different risks compared to investing in companies operating in the linear economy. An example for financing can be explained with the company Philips Lighting. The company does not sell the product, which is the light, but the customer pays a monthly fee for the lighting. If the contract ends, the lights are taken back (Philips Lighting, 2017b). The financing in this company is conducted in a different way. The customer pays a monthly fee, which creates a flow of smaller payments instead of one big payment upfront. These different financial risks need to be considered by investors. The Dutch government is currently conducting research in this field to get a better understanding of the financial risks and hurdles for a circular company. This creates more understanding in what a circular company needs from the government. For the measure knowledge and innovation, the government stimulates the creation of knowledge networks. The last measure that was mentioned, the international cooperation, comes with the point that if the Netherlands wants to change to a CE, the support and cooperation of countries in Europe and beyond the continent needs to be established.

In 2015 the European Union came with plans for the transition to a CE. The main areas of the measures that it takes are product design, production process, consumption, from waste to resources (secondary raw materials) and innovation, investment and other cross-cutting issues (European Commission, 2015). The European Commission states that CE can bring economic benefits, contributing to innovation, growth and job creation. An example of one of the measures that the European Commission took is the CE marking. The marking is placed on products that meet certain standards on safety, health and environmental protection. Two main benefits of this marking is that first, businesses know that those products can be traded in the European Economic Area (EEA) without any restrictions and second, consumers are able to enjoy the same level of requirements in this whole area. The EEA consists of the 28 European Union member countries, Iceland, Liechtenstein and Norway. Another example of a measure taken by the European Union is that the union launched the European Circular Economy Stakeholder Platform,

which “brings together stakeholders active in the broad field of the circular economy in Europe” (European Commission, 2015).

Besides national governments and unions, also other organizations exist with the goal to foster the transition to a CE. An example given earlier, the Ellen MacArthur Foundation, is a registered charity from the United Kingdom. But this is not the only organization that exists. Another British organization is the Waste and Resources Action Programme (WRAP), founded in 2000 to initially promote sustainable waste management (WRAP, 2018). Circle Economy aims to accelerate the transition to a CE, providing tools and programs to facilitate decision making and action plans for businesses and governments (Circle Economy, 2018a). Over the years, many organizations and knowledge hubs promoting CE have been established. In the Netherlands there is, amongst others, Holland Circular Hotspot and Circulaire Economie Nederland (Holland Circular Hotspot, 2018; Circulaire Economie Nederland, 2018). In Belgium there is, amongst others, Vlaanderen Circulair, which was previously called Plan-C (Vlaanderen Circulair, 2018).

2.4.2 | Circular Business Models or Business Models for Circularity?

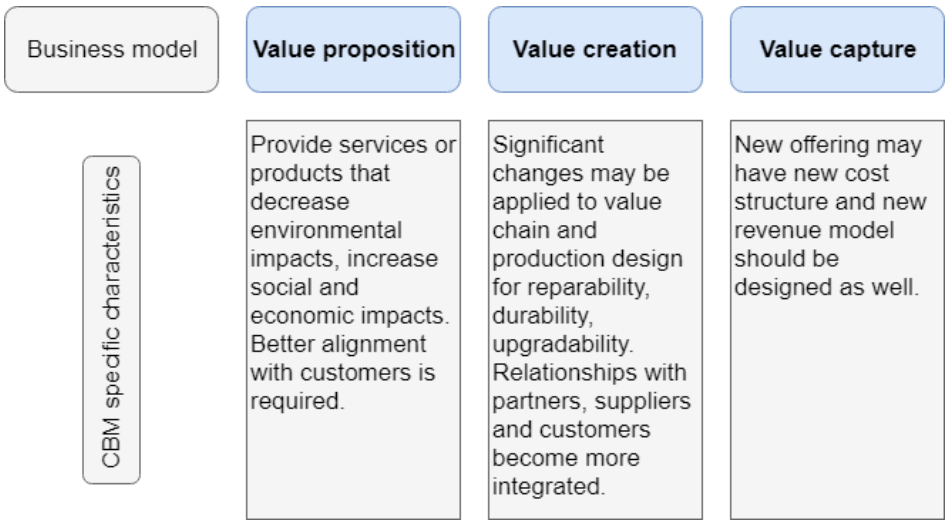
In order to make the transition from a linear economy to a CE successful, business model and design strategies need to go hand in hand (Bocken et al., 2016). Companies can involve in the transition by creating a circular business model (CBM). Linder & Williander (2017, p. 183) define a CBM as “a business model in which the conceptual logic for value creation is based on utilizing economic value retained in products after use in the production of new offerings”. Another definition of a CBM explains the concept as “the rationale of how an organization creates, delivers, and captures value with slowing, closing, or narrowing flows of the resource loops” (Oghazi & Mostaghel, 2018, p. 19). In this definition, aspects from both the definition of a business model as well as the definition of a CE are combined. Apart from the traditional business strategy, which is creating superior value for the customer and capturing a greater portion of that value compared to competitors, the CBM incorporates other aspects. CBMs have an economic, social and environmental aspect (Bocken et al., 2016). These aspects were defined by the authors in the following way:

- *Economic factors* – can save costs for customers and the firm by reusing, recycling, and using less materials/components/products;
- *Social factors* – involve sharing and reusing resources among members of society, and primarily among businesses, which in turn enhances interactions;
- *Environmental factors* – minimize both waste production and the use of renewable resources (Bocken et al., 2016).

An example of a CBM is the previously-mentioned Philips circular lighting. The company provides the product as a service, which means that the customer pays for the use of the product, thus the light, and not for the ownership of the light fixture. Philips Lighting takes the products at the end of the contract back and ensures the products, or parts of them, will be used elsewhere (Philips Lighting, 2017b). The concept of servitization is closely related to a product as a service model. This term was defined by Kowalkowski et al. (2017, p. 8) as "the transformational processes whereby a company shifts from a product-centric to a service-centric business model and logic".

What, besides the environmental aspect, makes CBMs different from linear ones? Another difference that is seen, is that companies with CBMs tend to have closer collaboration with their partners, suppliers and customers. In the example of Philips Lighting, it is important that the company stays in close contact with their customers. This is not a traditional business model where a product is sold and with that, it marks the end of the firm-customer relation between the two; the customer needs to update Philips if the lights are still working and if the contract does not get renewed the lights need to be removed. This points out the importance of customer interaction in a service model. Companies do not create value on their own, but in collaboration, and therefore CBMs could derive from collaborative ties. The three main differences of a CBM compared to a LBM are visualized in below Figure 4, retrieved from Oghazi & Mostaghel (2018). The authors adapted the original framework from Bocken et al. (2016).

Figure 4. Circular business model framework, retrieved from Oghazi & Mostaghel (2018)



The first CBM specific characteristic belongs to the value proposition part of the business model. It incorporates the three factors (environmental, social and economic) and puts forward that the customer relationship with the firm is crucial. In the value creation, the CBM is different because the relationship with partners and suppliers is more integrated than in most LBMs. Besides,

aspects as product design and durability of products plays an important role here. As mentioned earlier, the financial structure of a circular company can be different compared to a linear company. This aspect is placed in the value capture part of the framework.

So far, CBMs have been described as business models belonging to companies that have circularity in the core of their business and thus, it is part of their business model. However, there are examples of businesses that put circular activities into practice but do not position themselves as a circular company. An example is the TU Delft start-up Gerrard Street. The company specializes in circular consumer electronics. For a yearly or monthly fee, the customer gets a modular headphone. If a part of the headphone breaks, the company sends a new part to the customer as part of their service model (Gerrard Street, 2018). The main focus on the website of the company is the fact that they offer a high-quality product, whereas the circularity and the environmental aspect of the firm is not widely and extensively communicated. The reason for this is that the majority of customers do not have sustainability or circularity high on their criteria list when they make the decision for a new product or service (Ewen et al., 2017). Factors such as the functionality, price and quality of a product are generally more important for customers in their decision-making process than fair-trade, sustainability and circularity. Gerrard Street focuses therefore not too much on its circularity, but emphasizes on the outcomes of its circular activities, which are extended product life cycle, product modularity and higher quality.

To come back to the title of this section, "Circular Business Models or Business Models for Circularity?", and with the above paragraph in mind, it is necessary to establish a common understanding for the remainder of this thesis on how a CBM is identified. If a company has circular elements in its business operations, but does not necessarily put circularity in its business model, one could argue that "business model for circularity" is a better term. However, in this thesis, the term CBM will still be used. This is because such a company is still involved in the CE principles.

An overview of different CBMs was created by Lüdeke-Freund et al. (2018). In literature, 37 CBMs were found. However, some of those could be grouped together and the authors ended with a list of 26 CBMs (Table 2). Due to the grouping, in the first column of the table there may be multiple names for the same CBM.

Table 2. 26 CBMs retrieved from Lüdeke-Freund et al. (2018)

Circular business model	Description adopted from Lüdeke-Freund et al. (2018)
1. Circular supplies	Using own waste or waste of third parties as inputs
2. Classic long-life model	Designing long-lasting products
3. Closed-loop production	Continuous recycling of material
4. Co-product generation Another CBM that was grouped into this category: Multiple cash flows / multiple revenues	Co-products based on recycled waste, process residues or by-products
5. Cradle-to-cradle	Producing products with the cradle-to-cradle certificate
6. Create value from waste	Waste as production input
7. Encourage sufficiency	Long-lasting products and education of consumers to reduce consumption
8. Extending product value	Repairing, remanufacturing or recovering products
9. Extending resource value	Winning back base materials from waste for new products
10. Industrial symbiosis	Physical exchange of materials, energy, water and byproducts
11. Online waste exchange platform	Bringing together users and producers of waste
12. Product as a service Other CBMs that were grouped into this category: Product lease; Product renting or sharing	Unlimited access to a product (lease)
13. Product life extension	Designing, repairing, upgrading, remanufacturing and remarketing products
14. Product recycling/Recycling 2.0 Other CBMs that were grouped into this category: Recycling and waste management	Packaging that can be completely emptied or education of consumers to reduce waste
15. Product transformation	Winning back components from used products
16. Remanufacturing/next-life sales	Used products or components in as-new quality, restoring its functionality
17. Rematerialization	Winning back base materials from waste for new products
18. Refurbishment Other CBMs that were grouped into this category: Reuse / refurbish / maintain / redistribute / next-life sales; Reuse	Cheaper products, repaired equipment, spare parts
19. Resource recovery	Recovering products and materials at the end of one product lifecycle
20. Service and function-based models Other CBMs that were grouped into this category: Functional sales and management service models; Deliver functionality, rather than ownership; Functional result; Pay per service unit; Access and performance model	Switching from product to service, payments per use
21. Sharing platforms	Collaboration among product users

22. Take back management	Recyclable and decomposable products
23. Upgrading	Replacing outdated modules or components with superior ones
24. Waste exchange (external)	Using waste as an input between different firms
25. Waste exchange (internal)	Using waste internally as an input
26. Waste regeneration systems	Products based on recycled waste

Out of these CBMs, the authors derived six circular BMPs. These patterns will be presented in Section 2.6. The 26 CBMs will be used later in this thesis as input for the case survey protocol.

When researching the latest CE insights in literature, the topic of implementation issues comes up. In Chapter 1, the need for a change in how the economy is working at the moment was made explicit. However, the linear economy is still the status quo. Therefore, part of the literature review puts attention to implementation issues of CE. This is presented in the next section.

2.5 | CBM Implementation Issues

There are several drivers of implementing a CBM; these are, amongst others, cost savings in manufacturing, differentiation potential to meet low cost competition, enhanced customer relations, improved customer behavior understanding, improved margins, reduced environmental impact and increased brand protection (Linder & Williander, 2017). However, the focus of the authors was finding challenges and limitations for CBM innovation. The emphasis of this research are CBMs based on remanufacturing and reuse. This means that not all CBMs are used, as CBMs can also focus on e.g. recycling or refurbishment. The challenges and limitations that the authors found are:

- *Capital tied up* – in a service model the financial risk transfers from the customer to the producer. Cash flows are different and major upfront investments are needed;
- *Customer type restrictions* – this implies that there might be certain customers that have negative feelings about a remanufactured product and prefer brand-new products. These customers would choose a new product over a circular product, even when price, quality and other aspects are interchangeable;
- *Fashion vulnerability* – when a product is being remanufactured, it is harder to respond to fashion changes;
- *Lack of supporting regulation* – this is regarding policy, laws and regulations. Taxes tend to be levied on labor rather than raw materials;
- *Operational risk* – the firm partly takes over the liability and operational risk of the customer;

- *Partner restrictions* – a circular company needs to create understanding and incentives to work together for its CE practices with partners, e.g. suppliers. Apart from that, also trust amongst partners is needed and can be the cause of hurdles;
- *Product category restrictions* – this implies that some products are simply not suitable for reuse or remanufacturing;
- *Requires technological expertise* – when a company wants to remanufacture a product, considerable knowledge and expertise is required;
- *Return flow challenges* – predictability and reliability of the return flow are two big challenges here. Difficulties are formed in capacity planning;
- *Risk of cannibalization* – if a company produces new products that last longer, a decrease in sales of their old, shorter-lasting products could be observed (Linder & Williander, 2017).

Implementing a CBM comes with some extra, negative aspects that have to be considered compared to implementing a LBM. It was found that "validating a CBM always has a higher risk than validating a corresponding LBM" (Linder & Williander, 2017). Whereas a "normal" product has to be sold only once, a circular product has to be sold and reused or recycled before validation.

Another review on challenges for CBMs was executed by Oghazi & Mostaghel (2018). The authors found 16 challenges, of which some of them were already pointed out by Linder & Williander (2017). The not yet named challenges (7) are:

- *Confidentiality for individual firms* – information exchange can conflict;
- *Cultural barriers* – fear of the unknown from organizations and individuals;
- *Economic barriers* – different skills and resources that are needed might be more expensive;
- *Higher risks for CBM* – "validation is not achievable without later sales and that risk of resource exposal grows during validation" (Oghazi & Mostaghel, 2018, p. 21) Whereas "the cost structure of a linear business model only consists of costs for one-off manufacturing of the product, the cost structure in a CBM is dependent not only on the initial sale but also for sales after recirculation" (Linder & Williander, 2017, p. 191)
- *Increase of dependency to partners* – due to the collaboration more dependency is created, this is a risk;
- *Mutual benefits for all partners* – misaligned profit sharing along supply chain could hinder CBM adoption;

- *Organizational barriers* – change is difficult, restructuring a company is costly, risky and might cause resistance from employees.

Some of these challenges are unavoidable or due to the newness of CE and CBMs. However, Oghazi & Mostaghel (2018) present some propositions in order to overcome or decrease these hurdles. The authors' main points include putting customer engagement high at stake as well as making sure external linkages are seen as important. Moreover, the revenue model and the cost structure of companies needs to be reconfigured. Linder & Williander (2017) also note that some of their mentioned hurdles cannot be avoided due to fundamental differences between CBM innovation and LBM innovation. Managers of circular companies need to adapt to the difficulty of risk management for investments in CBM innovation, even though the risk adjusted return on investment might be good. However, this risk was not assessed further in the paper and needs to be further studied as well.

Another point regarding a limitation in the transition to a CE was mentioned by Roos (2014). The hurdle is described as follows: "mankind has many problems and they will normally not be solved until they become the problem of one man or one organization since mankind has no address nor bank account and hence, cannot provide an incentive for a firm to solve the problem" (Roos, 2014, p. 267). Moreover, the authors elaborate that a great amount of today's environmental problems can be solved with existing technology. However, these are currently not solved because there is no problem owner that will pay for the solution, even though there are huge advantages for the public. Firms tend to focus on their business being viable and in a lesser, or even none extent focus on being the problem owner of e.g. worldwide resource depletion. It is therefore important to note that firms will always put their own business first before worldwide issues.

As the limitations and challenges is an important aspect of the transition to a more circular economy, these findings will be used later in the case survey methodology in Chapter 3 and 4.

2.6 | Circular Business Model Patterns

Earlier, the BMPs were introduced as well as the CBMs. This paragraph is dedicated to circular BMPs in literature. An agreed definition for the term has not been established. However, the definitions of a CBM and a BMP can be referred to. To recall, a CBM was defined as "the rationale of how an organization creates, delivers, and captures value with slowing, closing, or narrowing flows of the resource loops" (Oghazi & Mostaghel, 2018, p. 19). BMPs are "business models with similar arrangements of business model Building Blocks, or similar behaviors" (Osterwalder & Pigneur, 2010, p. 55). CBMPs can be described as "business model Building Blocks" seen in

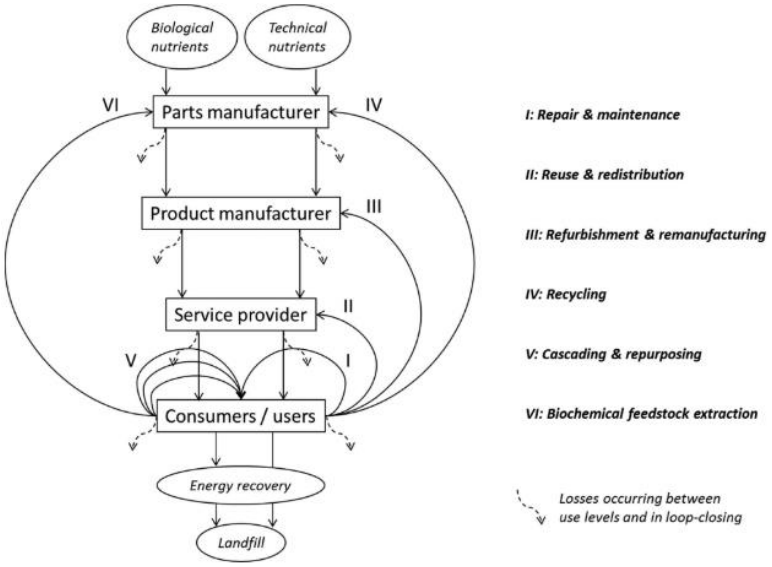
business models for circularity. As CBMs are part of business models, the same goes for patterns. Only patterns related to circularity are found to be CBMPs.

Earlier mentioned were the 26 CBMs from Lüdeke-Freund et al. (2018). From those CBMs, 6 CBMPs were derived. These were copied and definitions proposed by the authors are as follows:

1. *Cascading and repurposing* – desribes the iterative use of the energy and material contents of physical objects, leading to productive processes that are fed purely by external energy input;
2. *Organic feedstock* – organic residuals can be processed via biomass conversion, compositing, or anaerobic digestion. The last is a "process in which microorganisms break down organic materials, such as food scraps, manure, and sewage sludge, in the absence of oxygen" (EMF, 2012, p. 25; Lüdeke-Freund et al., 2018);
3. *Recycling* – can take different forms, namely down- and upcycling;
4. *Refurbishment and remanufacturing* – these are combinations of the repair and maintenance and the reuse and redistribution capabilities and business model design options (e.g., in terms of value delivery processes);
5. *Repair and maintenance* – companies involved with principles such as services for customers, using forward and reserve logistics, up-to-date product expertise, fast learning and problem-solving capabilities;
6. *Reuse and redistribution* – this entails that companies offer access to used products and evaluate the market value of their products, which might include slight enhancements or modifications, and creating a market place.

The first three patterns focus on closing the resouce loops and retain material value, whereas the last three patterns are about slowing resource loops and retain product value. The patterns are visualized in Figure 5 with the numbers I until VI. This is an adapted form of the CE overview figure by EMF (2012) (See Figure 3 in Section 2.4).

Figure 5. Six CBM patterns by Lüdeke-Freund et al. (2018)



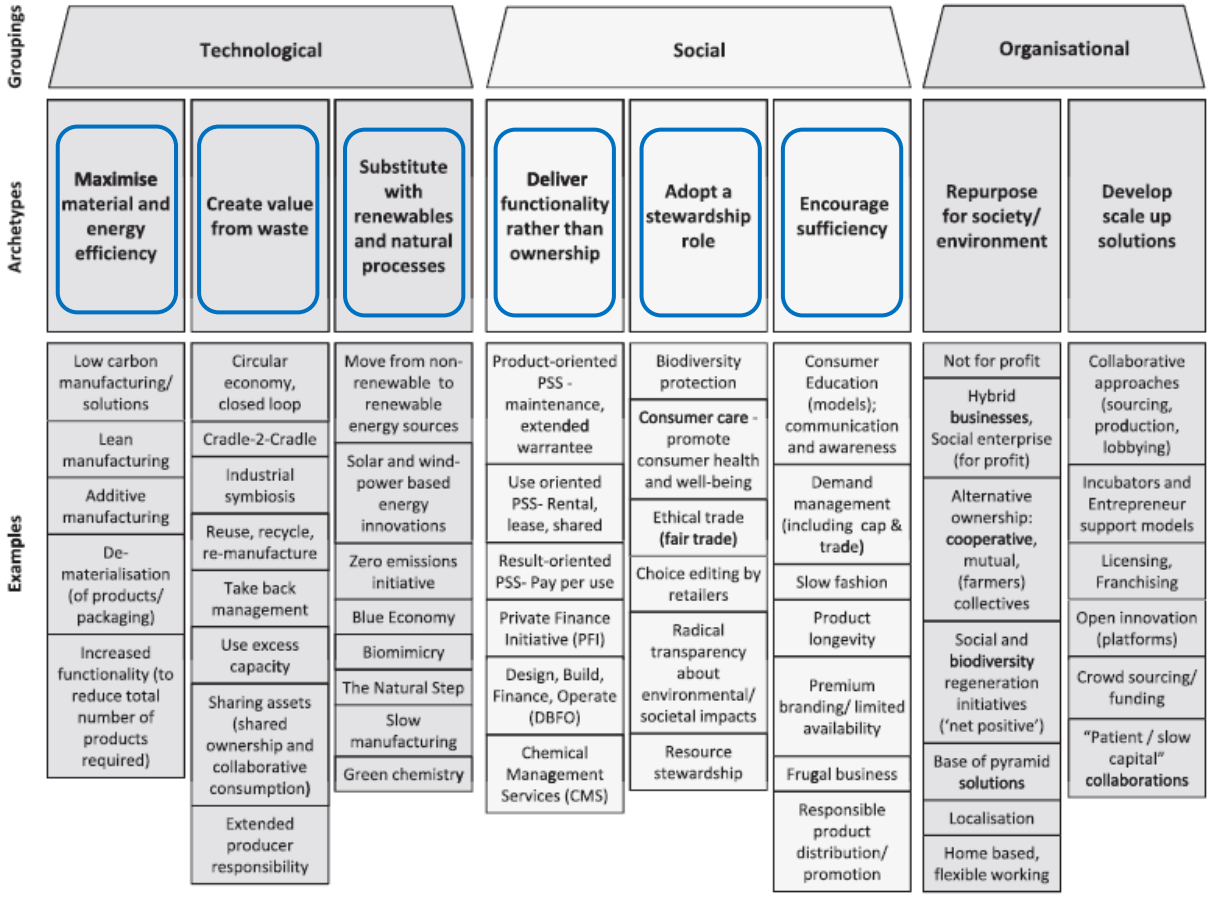
The figure above shows the relationships between different actors (put in boxes) in a product life cycle. Biological and technical nutrients are used for the manufacturing of the parts. The parts are used for the manufacturing of the product. The product is related to the service and the service is provided to the customers and users. In every stage, losses occur which are also visualized.

A paper on CBMs addresses business model strategies. The business model strategies and their definitions proposed by Bocken et al. (2016) are:

1. *Access and performance model* – providing the access or services to satisfy user needs without the customer to buy the actual physical products;
2. *Classic long-life model* – business models focused on delivering a long product life, which can be achieved by e.g. design for durability and repair;
3. *Encourage sufficiency* – solutions that actively seek to reduce end-user consumption by menas of e.g. durability, upgradability, service, and reparability or a non-consumerist approach to marketing and sales, e.g. no sales commissions;
4. *Extending product value* – exploting residual value of products, from manufacture, to consumers, and then back to manufacturing, or collection of products between business departments;
5. *Extending resource value* – exploiting of the residual value of resources: collection and sourcing of otherwise "wasted" materials or resources to create new ways of value;
6. *Industrial symbiosis* – a process-orientated solution, concerned with using residual outputs from one process as feedstock for another process, which benefits from geographical proximity of businesses (Bocken et al., 2016).

The first four are business model strategies for slowing loops and the last two for closing loops. The narrowing of loops was not mentioned. This list of patterns can be extended with an overview of eight business model archetypes that were introduced to describe groupings of mechanisms and solutions that may contibute to building up the business model for sustainability (Bocken et al., 2014). The archetypes are shown in Figure 6.

Figure 6. Business model archetypes for sustainability from Bocken et al. (2014)



The uppert part of the image divides the archetypes into three groups: technological, social and organizational. Examples of the archetypes are also shown. For companies involved in CE, the archetypes in the technological and social groups are suitable. This means that six archetypes can be added: three archetypes from the technological grouping (maximize material and energy efficiency, create value from waste and substitute with renewables and natural processes) and the three process from the social group (deliver functionality rather than ownership, adopt a stewardship role and encourage sufficiency). The six added archetypes are indicated with a blue contour.

The six patterns from Lüdeke-Freund et al. (2018), the six CBM strategies from Bocken et al. (2016) and the six business model archetypes for sustainability from Bocken et al. (2014) combined form 18 CBMPs. However, in this list some duplicates exist. In Section 2.8 the patterns were narrowed down to a number of 11. These 11 CBMPs are the last main finding of the literature review and will be used in the case survey. First, the main findings are going to be recalled in Section 2.7.

2.7 | Main Findings Literature Review

In this paragraph the main findings and the most important information that is needed to answer the first two sub research questions will be addressed. This chapter started with an approach to the literature study. It explained how and where the literature study was executed. Next, the definitions of a business model, BMI and BMI tools were given. Thereafter, the BMPs were explained and a taxonomy was given. After that, the business model part was finished and the CE and CBMs were introduced. Some examples of countries and unions were presented that are taking action in the transition to CE. In the paragraph on CBMs it was noted that all companies that are contributing to the transition to a CE are incorporated in the list of CBMs. An overview of 26 CBMs was found and a list of in total 18 limitations and challenges regarding CBM implementation. After that, several papers regarding patterns in CBMs were studied to provide the overview of CBMPs. The information gained from the literature study that is going to be used in the case survey methodology is:

- 26 CBMs (Lüdeke-Freund et al., 2018);
- 18 imitations and challenges for CE implementation (ten from Linder & Williander (2017), seven from Oghazi & Mostaghel (2018) and one from Roos (2014);
- 11 CBMPs (Initially six from Lüdeke-Freund et al. (2018), six from Bocken et al. (2016) and six from Bocken et al. (2014), regrouping takes place in Section 2.8).

2.8 | Answers to Sub Research Questions 1 and 2

With this literature review, the first two sub research questions can be answered. The answers to these questions are important for the rest of the research.

The first sub research question was: *What are the main developments on circular business models in scientific literature and the barriers in implementing them for companies?* A short conclusion on the main findings in this chapter have been given in Section 2.7. This chapter provided definitions and explanations to generic business model and CE concepts. Also, this chapter presented the differences between CBMs and LBMs. Oghazi & Mostaghel (2018) presented three main

differences between CBMs and LBMs. The authors explained these differences in characteristics that a CBM contains. The first one is that in the value proposition part of the business model, companies try to decrease environmental impacts and at the same time try to increase social and economic impacts. This requires better alignment with customers. The second characteristic is placed in the value creation part of the business model and concerns changes to the value chain, such as increased durability and upgradability. Here, better alignment with partners and suppliers is required. The last characteristic is about value capture. The CE needs new cost structures and new revenue models. Therefore, CBMs can be seen as LBMs with some extra aspects focused on the environment, the public and the economy itself. The literature review also provided a list of 26 CBMs, which are going to be used further in this thesis.

The second part of this question focuses on implementation barriers. Different papers on CBM implementation barriers have been studied and a list of 18 problems has been established. Some of these problems, such as risk of cannibalization, may also form an implementation barrier for linear companies. This risk means that if a company produces a product that lasts longer, a decrease in sales of their old, shorter-lasting products could be observed. Other problems can be directly related to the changes presented in the section above. There it was said that better alignment between partners is needed. One of the implementation barriers is 'increase of dependency to partners', which is something that follows from the CBM characteristics.

The second sub research question to be answered with the literature review is: *What are circular business model patterns and which patterns are identified in scientific literature?* Combining the definitions of CE and BMPs, the following definition for a CBMP was established: "building blocks in business models for circularity". In total 18 patterns were found, however, regrouping has to take place as duplicates exist in this list.

The full list of patterns is as follows:

1. *Access and performance model*
2. *Adopt a stewardship role*
3. *Cascading and repurposing*
4. *Classic long-life model*
5. *Create value from waste*
6. *Deliver functionality rather than ownership*
7. *Encourage sufficiency*
8. *Encourage sufficiency*
9. *Extending product value*
10. *Extending resource value*
11. *Industrial symbiosis*
12. *Maximize material and energy efficiency*
13. *Organic feedstock*
14. *Recycling*
15. *Refurbishment and remanufacturing*
16. *Repair and maintenance*

17. *Reuse and redistribution*
18. *Substitute with renewable and natural processes*

These patterns were adopted from several papers (Lüdeke-Freund et al., 2018; Bocken et al., 2016; Bocken et al., 2014). However, some of the patterns are duplicates. Pattern number 8 'Extending product value' is part of the overarching pattern number 3 'Refurbishment and remanufacturing', and is one of the features that this overarching pattern owns. Pattern number 9 'Classic long-life model' is part of the overarching pattern number 1 'Repair and maintenance', because maintenance increases product life. Pattern number 10 and 18 'Encourage sufficiency' are grouped together to pattern 13 'Maximize material and energy efficiency'. Pattern number 11 'Extending resource value' and pattern 14 'Create value from waste' are both part of the overarching pattern 4 'Recycling/create value from waste'. Pattern 16 'Deliver functionality rather than ownership' merged with pattern 7 'Access and performance model', as they imply the same concept. The concept here is the change of product ownership from the customer back to the company. This means that after the regrouping the number of patterns in the list is downsized to 11. The list of patterns that is going to be used in the rest of this research is, including its definitions:

1. *Access and performance model/deliver functionality rather than ownership* – providing the access or services to satisfy user needs without the customer to buy the actual physical products;
2. *Adopt a stewardship role* – taking a stedwardship role promoting e.g. biodiversity protection, consumer care (consumer health and well-being), ethical and fair trade and radical transparency about environmental/societal impacts;
3. *Cascading and repurposing* – desribes the iterative use of the energy and material contents of physical objects, leading to productive processes that are fed purely by external energy input;
4. *Industrial symbiosis* – a process-orientated solution, concerned with using residual outputs from one process as feedstock for another process, which benefits from geographical proximity of businesses;
5. *Maximize material and energy efficiency* – when companies are involved in principles such as low carbon solutions, lean manufacturing, additive manufacturing, de-materialization (of products/packaging) and increased functionality (to reduce the total number of products required). This also includes solutions that actively seek to reduce end-user consumption;

6. *Organic feedstock* – processing of organic residuals via biomass conversion, compositing, or anaerobic digestion;
7. *Recycling* – can take different forms, namely down- and upcycling. Downcycling means the recycling process converts the product in something with a lower value, upcycling is the other way around;
8. *Refurbishment and remanufacturing* – these are combinations of the repair and maintenance and the reuse and redistribution capabilities and business model design options (e.g., in terms of value delivery processes);
9. *Repair and maintenance* – companies involved with principles such as services for customers, using forward and reserve logistics, up-to-date product expertise, fast learning and problem-solving capabilities;
10. *Reuse and redistribution* – this entails that companies offer access to used products and evaluate the market value of their products, which might include slight enhancements or modifications, and creating a market place;
11. *Substitute with renewable and natural processes* – Moving from non-renewable to renewable energy sources, using power from wind and solar, zero emissions initiatives, slow manufacturing etc.

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Chapter 3 | Case Survey and Interview Methodology

In this chapter the main methodology of this research, the case survey, is presented. Also semi-structured interviews will be held, these are shortly introduced in this chapter as well. After answering the first two sub research questions in Chapter 2, this chapter continues with the gained insights from the literature study to answer the third and fourth sub research question. The chapter starts with explaining the case survey method in Section 3.1. After that, the main arguments for choosing this particular method as well as its limitations are presented in Section 3.2. In Section 3.3, a practical example of a case survey study will be shown to illustrate the steps that are needed in the process. This chapter describes the process of case study sourcing, presents the reader the selection criteria and gives an overview of the selected case companies in Section 3.4. After that, the process of the survey development and the establishment of the coding scheme, or protocol, is presented in Section 3.5. Section 3.6 elaborates on how the coding was executed. An introduction on how the data will be analyzed in shown in Section 3.7. Section 3.8 elaborates on the semi-structured interviews that will be held after the case survey has been executed. Section 3.9 presents how the methodology and findings are shown in the appendices.

3.1 | The Suitable Methodology

The main topic of this research is the study of CBMPs in existing circular companies. In Chapter 2, the first two sub research questions were answered. As was presented in Section 2.7, the main findings of the literature review for the case survey are as list of 26 CBMs, 18 imitations and challenges and 11 CBMPs. This chapter presents the methodologies to answer the third and fourth sub research question, which are:

- Sub research question 3: *Which circular business models, circular business model patterns and implementation barriers can be identified in business practice?*
- Sub research question 4: *How can circular business model patterns stimulate more widely adoption of circular business models and how can this contribute to a transition to a more circular economy?*

The third sub research question will be answered using the case survey, this methodology is presented in the sections 3.1 until 3.7. The fourth sub research question will be answered with semi-structured interviews as presented in Section 3.8.

To answer the third question, an amount of circular companies needs to be studied on their business model. This could be executed with a case study, since that will generate a thorough and in-depth understanding of the business model of the organization. However, this method is time-consuming and within the time frame of this research, only a couple of case studies could be conducted. With the results of only a couple of case studies it will be hard to generalize gained information to other companies and draw conclusions on CBMPs. Another method should be used that is able to study a larger amount than e.g. 2 to 5 single case studies.

The case survey methodology was found to be suitable for this research project. Yin & Heald (1975) were one of the first to mention this method, which fits studies with a heterogenous collection of case studies. With this method, the task of the researcher is to aggregate case characteristics presented in individual cases. The method is a form of meta-analysis because it translates qualitative data from single case studies to quantitative data that can be analyzed. It "can overcome the problem of generalizing from a single case study and at the same time provide more in-depth analysis of complex organizational phenomena than questionnaire surveys" (Larsson, 1993, p. 1516). Using a designed coding scheme with closed-end questions, single studies can be coded. The results of the case survey will be cumulation of case study knowledge as well as theory development and/or extension (Jurisch et al., 2013). Conducting a case survey was broken down by Larsson (1993) into the following twelve steps:

1. Developing initial research questions;
2. Case selection criteria;
3. Case sample collection;
4. Designing the coding scheme to convert the cases into variables;
5. Coding the cases through multiple raters;
6. Coding the cases through multiple raters participating authors;
7. Measuring interrater reliability;
8. Resolving coding discrepancies;
9. Statistically analyzing the coding validity;
10. Statistically analyzing the impact of specific case study characteristics;
11. Statistically analyzing the created case data set;
12. Reporting the study.

Another overview of the method in the form of five stages was proposed by Jurisch et al. (2013). Their overview will be used as the starting point of this method in Section 3.3.

Case surveys have been used in business model research before. De Reuver et al. (2009) studied business model dynamics in 97 cases and found that technological and market-related forces are the most important drivers for business model dynamics. Another study analyzed business model innovation in SMEs in order to recognize drivers and resulting changes in a companies' business model innovating process, using 28 cases (Bouwman et al., 2017). In the field of business ethics, Miska et al. (2016) studied the moderating role in the situational and organizational context in determining unethical managerial behavior using a case survey. They researched 52 case studies and found that moral intensity and situational strength help explain the contextual effects.

3.2 | Strengths and Limitations of the Case Survey Method

Before continuing with how this methodology is further conducted, the strengths and limitations of the case survey methodology are presented. Especially the limitations are considered to be important to note, since those will also play an important role in the concluding part of this thesis on how to interpret the main findings. An extensive review on the case survey by Larsson (1993) provided strengths for this method. First, as was mentioned before, the case survey overcomes large drawbacks of single case studies. One drawback being that it is not possible to examine cross-sectional patterns and the other drawback that without these patterns, it is not possible to generalize to a larger population. Within the time frame of this research, only a couple of extensive case studies could be conducted. Second, this method combines earlier executed research efforts that were reported in different case studies that contain relevant data. Third, single case studies can be rich in detailed information studying complex phenomena, the case survey capitalizes all this information. Fourth, when case studies from different years are used, the patterns in time of complex phenomena can be analyzed. Last to mention, a strength from a broader perspective, is that the case survey method can be seen as a bridge over traditional research gaps, such as those between quantitative and qualitative methods.

In the same article Larsson (1993) studied and named limitations of the method. The first limitation explains that there is a limited number of available case studies, and that related case studies might not contain the information that is needed for the research. The second limitation is that with a case survey, a secondary investigator does not select the cases, as this has been done by the first researcher. The secondary investigator is only involved in the coding of the same cases as the first researcher did, a step that follows after case selection. Therefore, case surveys are unlikely to achieve theoretical and statistical generalization. A third drawback is that (single) case studies do mostly not provide all collected data due to space limitations. Information might be missing. The fourth limitation is that the quality of the case survey research can never exceed the quality of the individual case studies it analyzes. This point was also brought up by Yin & Heald

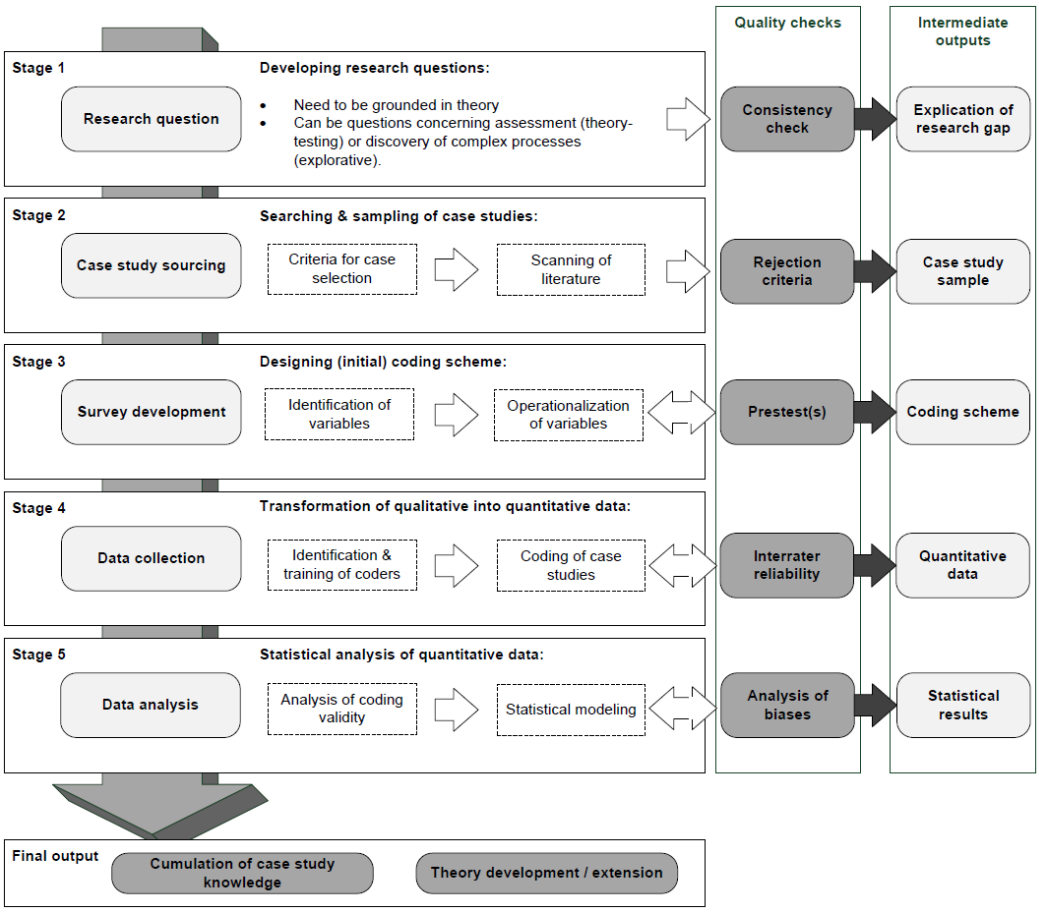
(1975). Last to mention is that the coding procedure of assigning numbers or categorizing variables can unduly simplify the complex phenomena that are being studied.

With quick desktop research it was found that many case studies on circular companies exist. With a case survey, this existing information will be combined and analyzed. Even though there are some strong limitations to the method, for this research the pros outweigh the cons. Existing case studies on circular companies containing insights on their CBM will be studied. If a large amount of cases is studied, the patterns found in the business models can be compared. Therefore, this method was found to be suitable for this research.

3.3 | Overview of the Case Survey Method

By establishing a detailed step-by-step approach replicability of the research is possible. Larsson (1993) proposed a step-by-step approach to go through the case survey method, that was shown in Section 3.1. Another way of presenting the case survey methodology was executed by Jurisch et al. (2013) with a visualization seen in Figure 7. The authors introduced the case survey method as a new mode of inquiry to supplement information systems review methods. Due to the fact that the visualization is presented in a very clear way, it will be used as the outline of this research.

Figure 7. Case survey methodology overview of Jurisch et al. (2013)



The authors divided the process into five stages and showed graphically the intermediate and final outputs. Stage 1, regarding the development of research questions, has been done in Chapter 1. In the second stage the researcher searches for case studies in literature and determines the selection criteria. After discarding the case studies that have not made it, the case sample has been established, which is the intermediate output for Stage 2. In Stage 3 the coding scheme is designed. In this stage the researcher needs to determine what information and characteristics are needed from the cases. The scheme will be in the form of a protocol and describes systematically how the researcher needs to conduct the research. During the fourth stage, the researcher fills in the protocol for every case study and thus translates the case study reports' qualitative data to quantitative data. The data that is gained will be the output for that particular stage. In Stage 5, the data analysis is executed.

As noted before, Stage 1 was completed in Chapter 1 and the two sub research questions that are answered with this method were recalled in Section 3.1. Now, this chapter will continue with the rest of the stages. Stage 2, case study sourcing, will be elaborated on in Section 3.4. Stage 3, survey development, follows in Section 3.5. Data collection, Stage 4, is presented in Section 3.6. How the data will be analyzed, which is the last stage, is shown in Section 3.7.

3.4 | Case Study Sourcing

The goal of the case study collection is to find as many case studies as possible from as many resources as possible. With this in mind, the question of sample size comes up. A logical question would be what the minimum amount of case studies should be. Jurisch et al. (2013) reported there is no established minimum in literature for a case survey. The authors found case surveys with 61, 50 and 33 cases in other researches. De Reuver et al. (2009) conducted a case survey with 97 cases, Bouwman et al. (2017) used 28 and Miska et al. (2016) 52. If the amount of case studies gets too large, less time can be spent on one single case and thus less information and knowledge can be obtained from it. On the other hand, when only a small number of cases is used in a case survey it becomes hard to draw general conclusions from the results. With the time frame in mind, it was decided that between 30 and 40 would be a realistic number of cases to draw insightful conclusions from.

To find enough cases, desktop research was conducted to find an overview of sustainable and circular companies. The aim was to find as many companies as possible, so multiple databases and resources were used. Amongst others, the search for circular and sustainable companies was executed in the following ways:

- Published case studies of the Ellen MacArthur Foundation, a registered UK charity that was founded to foster the transition to a CE by Dame Ellen MacArthur;
- Published case studies on the TU Delft repository, a database containing (master) theses and research articles from the university;
- The book Route Circulair by Ewen et al. (2017) that studied 31 companies and their CBMs in the Netherlands;
- White papers and grey literature on CE by e.g. ABN AMRO, Rabobank and Accenture;
- Circular organizations/hubs, such as Circulaire Economie Nederland, Netherlands Circular Hotspot, Circulair Ondernemen, Vlaanderen Circulair (previously called: Plan C) and the European Union;
- Academic research papers found on e.g. Scopus, Research Gate and Google Scholar;
- Google searches with companies + "business model" or "circular economy", looking for more company information.

The result of this search was a database of 188 companies located worldwide. The companies ranged from small to large and recently founded to fully established. At this point, no selection was executed. The next step is to establish the criteria for cases that are going to be studied. In the first search, every circular company was added to the database. The development of selection criteria is an important step in the research, because it is highly prone to bias. Therefore, the criteria are described as thoroughly as possible. The following lists provides four selection criteria, the fifth point is not a minimum criterium but was added as an important note that has to be kept in mind during the selecting process:

1. *Enough information should be available* – when there is too little information available of a company, the case has to be discarded. The minimum information that is needed includes aspects as the company name, country or origin, its circular principles and operations, the operating industry and generic information about its business model;
2. *At least three information resources need to be conducted* – this criterium adds to the first one. As an example, it is possible that a company is featured on the website of a circular organization with a lot of information available. However, to decrease the bias that the article may contain, at least two other resources should be added so that a fair and real coding of the case company can take place;
3. *Information should be available in either Dutch or English* – a limitation in this research lies in the fact that only resources in Dutch or English can be addressed;
4. *All companies with circular activities or operations should be included* – the company does not necessarily need to present itself as a circular company, provided that the company

does operate circular. That a company decides to not present itself as circular has to do with the fact that the majority of customers do not have sustainability or circularity high on their criteria list when they make the decision for a new product or service (Ewen et al., 2017). There are examples of circular companies that do not put their circular perspective on their website or do not actively promote it, but instead focus on outcomes of their circular activities such as extension of the product life, product modularity or higher quality. These aspects are considered more important by their customers. The criterium that is set here, is: do not discard a company due to no mentioning of CE on their website, when their activities and operations can be considered circular;

5. *Companies are not selected based on (monetary) performance* – it is important to note that companies that are not performing well or even went bankrupt can be still interesting for this research. These companies should also be collected. However, successful stories about companies are probably more available than stories about companies that are not doing well. This fact should also be noted when analyzing the results of the study: the results may be too positive due to a wrong and too positive representation of reality.

After desktop research a large database of circular and sustainable companies was created that contains 188 companies. These are shown in Appendix A. After that, the selection took place. The final sample consists of 34 companies and is shown below in Table 3.

Table 3. Selected case survey companies

Selected companies			
Aquafil	Desso	Interface	REEP Technologies Ltd.
Auping	DSM Niaga	Kalundborg Symbiosis	Refuse Vehicle Solutions
Autocraft Drivetrain Solutions	Ecovative	Maersk Line	Replenish
Black Bear Carbon	Fairphone	Mazuma Mobile	Re-Tek
Braiform	Fat Lama	Mobility Carsharing	Rype Office
Brocklesby	FLOOW2	MUD Jeans	Splosh
Caterpillar	Furnishare	Park 20/20	The Plant
Cisco	GameStop	PeerBY	
Coca-Cola Enterprises	Greenwheels	Philips Lighting	

The selection took place based on the selection criteria mentioned before. A starting point to go from the longlist (188) to the shortlist (34) were the case companies featured on the website of the Ellen MacArthur Foundation. The website provided detailed information about the circular activities and business model characteristics of the companies. During the search for case studies,

articles, theses and books were found that studied multiple cases. Examples of companies that were present in many different resources are Philips Lighting (10 resources found), Desso (5), Ecovative (5), Interface (5), Maersk Line (5) and MUD Jeans (5). These companies were selected based on the rich amount of (different) data. For the other case companies in the sample, three or four information resources were used for the analysis. Companies where no more than two information resources could be found were discarded, as this was a selection criterium. The researcher made sure there was a mix between start-up and established companies as well as an about even division in small and large companies. Kalundborg Symbiosis, Park 20/20 and The Plant can be better defined as an umbrella organization of multiple companies. The inclusion of these organizations is due to the fact that industrial symbiosis is a part of CE and according to the researcher, should be included in the shortlist to provide a broad differentiation of companies.

3.5 | Survey Development

In this step the variables of the case survey are developed. These variables are included in the protocol and will provide the information that will answer the research questions. Previous case survey research has been studied to find examples of case characteristics and variables that were used. The case survey protocol of De Reuver et al. (2009), which researched business model dynamics, contained the following background variables: company size, age, strategy, culture, technology fit, industry sector and innovation type. The other variables in the protocol were described as driver variables and belonged to the research interest.

The following background variables are included in the protocol: company name, country of origin, industry sector, company size and company phase. The background variables are referred to as Part 1. With company size, the researcher can choose between small and large. For small companies, that means it employs less than 150 people. The company phase categories are start-up and established. The other variable category, Part 2, is research-specific. Here is where the findings of the literature study in Chapter 2 get involved. Besides the CBMPs, the two other lists of CBMs and the limitations and challenges were found. It was decided by the researcher to implement these findings in the case survey protocol, which could broaden the scope of the research. Therefore, the second category consists of three variables: the circular business models (27 choices), the limitations and challenges (19 choices) and the circular business model patterns (11 choices). The complete coding scheme and its choices can be found in Appendix B.

3.6 | Data Collection

In this part of the protocol, the actual coding of data is executed. The researcher scans and examines collected data from the information sources that were listed in Section 3.4. With this

information, the researcher can fill in the protocol. There are three possibilities for the researcher to fill in: applies to the case company (1), does not apply (0) and unknown/not applicable (-). This last option is for cases in which a variable cannot be found within the company's information or when the variable is only vaguely described. In the case of conflicting data, where one resource states something else as the other, this should be reported and discussed. A possibility here is that over time certain aspects change for a company. Than the most recent resource should be used. The quality check mentioned by Jurisch et al. (2013) in this stage is interrater reliability. Interrater reliability can be established when the coding of all, or at least part of the case studies is executed by multiple, independent raters. The multiple codings of the same case study can be analyzed afterwards to see to what extent the raters agree. When there are discrepancies, the raters have the possibility to discuss that with each other and come to a common understanding. This discussion should be documented. With this quality check, the chance of bias involved in the process is decreased. This researched is conducted by only one researcher, therefore it will not be possible to receive interrater reliability. This is an extra drawback of the methodology and is elaborated further in the discussion chapter of this thesis.

To provide a validity check, the researcher will contact the case study authors to discuss the filled in protocols with them. The contacted authors will not be asked to fill in the protocol the same way as the researcher did, but they will have a look at how the case was coded and decide if they agree with it or not. In the case of variables that cannot be found, this creates a perfect moment to ask for the missing information. This can say something about the confidence the researcher has about the results. This validity check is further presented in Section 4.2.

3.7 | Data Analysis

This section elaborates on what kind of analysis will be performed on the dataset. The researcher will start with giving a generic look on the different countries, sizes and phases in the case sample. If it is the case, the researcher can elaborate on underrepresented subcategories. The researcher will continue looking at the different industries and shortly discusses what kind of companies were studied. In short, the researcher walks the reader through the first part of the protocol. The second part of the protocol exists of the research-specific variables. Tables will be shown with the different CBMs, challenges and limitations and CBMPs and the number of case companies those variables were assigned to. This can say something about how much a certain business model pattern is seen in the dataset and which of the variables are not seen much. In the protocol there is also space for other CBMs, limitations, challenges and CBMPs. In the case where the researcher could identify a non-specified variable, this will be reported.

3.7.1 | Hierarchical Cluster Analysis

After that, hierarchical cluster analysis will be used with the help of the statistical program Statistical Package for the Social Sciences (SPSS). This is for visualization of the possible relations between the variables. In cluster analysis, data is separated into groups whose identities are not known in advance (Wilks, 2011). A central point to cluster analysis is distance. For the analysis, a common distance measure called the squared Euclidean distance is used. In hierarchical cluster analysis, the groups are constructed hierarchically. The outcome of this method is a dendrogram or tree diagram. This is a "graphical representation of the results of a hierarchical procedure in which each object is arrayed on one axis, and the other axis portrays the steps in the hierarchical procedure" (Hair et al., 2014, p. 416). It starts with each variable represented as a separate cluster, and then shows how these clusters are combined. The last step in this procedure is that all variables are represented in one single cluster. Therefore, variables closely related will be put next to each other. This method will be used in this research to examine the possibility to cluster CBMPs with CBMs and CBMPs with the limitations and challenges. It has to be kept in mind that cluster analysis will always create clusters, even when there is no existence of any structure in the data. No minimum amount of variables is needed for cluster analysis, however, scholars agree that a moderate or large sample size provide significant results. Regarding the small sample size of this research, this is important to note.

3.7.2 | Chi-Square Tests

Another statistical method will be used called the chi-square (χ^2) test. It is a nonparametric test and indicates whether or not an observed pattern is because of chance (Sekaran & Bougie, 2010). In this test a comparison is made between the observed frequency and the expected frequency, which the latter is based on probability. With this test it can be determined if two discrete variables are associated. In the case of an association, the distribution of one variable will differ depending on the value of the second variable (Hair et al., 2014). The output is a statistic and a level of significance and will be generated through SPSS as well. For interpretation the results of this test: when the χ^2 statistic is small it supports the assumption of no observed pattern, because observed counts and expected counts would be similar. When the observed counts differ from the expected counts, a large value of the χ^2 statistic will be the result and would support the assumption of an observed pattern. It is harder to show statistical significance for small sample sizes compared to larger ones. This has to be kept in mind regarding the small sample size (N=34) of this research.

3.8 | Semi-Structured Interviews

To gain more knowledge on the topics discussed and researched in this thesis and to extend the knowledge that can be obtained from the case survey method, semi-structured interviews will be held. The goal of these interviews is to find validation for the results of this research and to elaborate on the relevance for circular business model patterns regarding the CE transition. The interviews are with two academic researchers pursuing a PhD in the field of CBMs. Notes and insights of the interviews will be used in Chapter 4 (Section 4.11).

3.9 | Presentation of the Results

Four appendices were created to present the information and results of the case survey method and one for the semi-structured interviews. Appendix A shows the longlist of 188 circular and sustainable companies that were found for the research. In Appendix B, the case survey protocol is given. This includes all the variables that are going to be researched. The operationalization of the method is shown in Appendix C. Here, all the definitions of the variables are shown, so that the reader and a second investigator get information on how the coding was executed. The actual companies that made it to the shortlist, are found in Appendix D. Furthermore, this appendix gives all the results of the survey: which companies were selected, a short description on what they do, the survey results and a list of information resources that were used for the assessment. For the semi-structured interviews, the interview set-up is shown in Appendix E and includes some general information for the interviewee and the interview questions.

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Chapter 4 | Results of the Case Survey

In this chapter the results of the case survey are presented. The coding tables of the case survey are shown in Appendix D. This chapter starts with some general notes regarding the coding of the case survey in Section 4.1. After that the notes from the contacted case study author are presented in Section 4.2. An example of a case is shown in Section 4.3. The different countries, sizes and phases are shortly discussed thereafter in Section 4.4. Afterwards, the industries in the dataset are examined in Section 4.5. Following, the results of the CBMs (Section 4.6), the limitations and challenges (Section 4.7) and the CBMPs (Section 4.8) are addressed. Section 4.9 presents the hierarchical clustering of CBMPs to CBMs and CBMPs to the limitations and challenges. Section 4.10 presents the chi-square tests that were performed. In Section 4.11, the outcomes of the interviews with two academic researchers are shown. Finally, Section 4.12 is dedicated to answer the third and fourth sub research question.

4.1 | General Notes on the Coding

In general, the information for the companies was sufficient enough to get a good impression on the work of the companies and their business model. Only for REEP Technologies there was not much case material found and not much was shown on its website. However, the criterium of at least three information resources was met, and the researcher could make up the companies' business model. But this was only with the bare minimum amount of information.

In Chapter 3 it was mentioned that it should be discussed if different information resources on a company conflicted with information. The result is that no conflicting information was found. However, some companies were examined with information from a long time ago. This was the case for Greenwheels with a news article from 2004 (Emerce, 2004), for Mobility Carsharing with a 2008 article that was used that studied innovative business models (COWI, 2008) and for Interface, where one of its information sources was used from 2008 that looked at sustainable business models (Stubbs & Cocklin, 2008). The information in this resources did not conflict with 'later' information, but this 'later' information stated more about the companies' current business model and was therefore used more.

In the protocol there was room for business models, challenges and patterns that were not mentioned in literature, but were applicable to the companies. This was the last option for every variable ("Others, namely …"). This option was used a couple of times and is incorporated in the sections on the research-specific variables (Sections 4.6–4.8).

4.2 | Notes from Case Study Authors

As it was not possible to add a second coder to this research, as a master thesis project is done on an individual basis, a different kind of check for the codings had to be found. In Chapter 3 it was introduced that case study authors would be contacted so that they could comment on the case survey findings.

A sample was done and one case study author was asked to look at the case survey results. In the work of the author two companies (Black Bear Carbon and DSM Niaga) were analyzed and this work helped the researcher filling in the protocol. The comments of the author could have led to three options: first, the author could state that the researcher is totally right in the coding, second, the author could state that major changes are need or three, only minor changes are needed. It was the third option in this case. It was found that, as their sample was smaller, the case author had done more research into the companies. They gained much information from e.g. interviews, of which part was not reported in their final work. For one company a business model variable and a problem variable was added; for the other only a business model variable was added. This entails that the researcher did the coding, according to the author, right, but missed on some small details that the case author knew about but were not mentioned in the case material. What does this say about the reliability of the results? It can be said that involving case authors could increase the reliability of the results with extra information, but with the current research done the researcher had a proper overview of the companies' business model. Due to time limitations only one case author was contacted. The case author's comments have been added to the two company descriptions in Appendix D.2.

4.3 | Example of a Case Company: Replenish

An example of a case company is given in this section to order to create understanding for the reader how the cases were coded and what information was obtained. The chosen example is Replenish, a company from the United States operating in the fast-moving consumer goods (FMCG) and packaging industry. The small start-up tries to eliminate the waste of plastic bottles and its solution is a reusable packaging bottle that is designed to mix liquid concentrate refill pods with water shown in Figure 8. This product has a cradle-to-cradle certificate and was therefore assigned the corresponding business model (CBM6). It wat assigned CBM7 (Encourage

Figure 8. Replenish bottle retrieved from its website

efficiency) because the customer is able to buy refill packages for the bottle: by adding water the cleaning product is created. The bottle has to purchased once and will be refilled when the cleaning product is gone. The problems this company experiences are 'Product category restrictions' (LIM15) and 'Requires technological expertise' (LIM16), the first because not all different cleaning products are able to be refilled like this one and the latter because of the chemistry expertise the company needs to have in order to create this. The CBMPs the company was assigned to are 'Adopt a stewardship role' (CBMP2), 'Cascading and repurposing' (CBMP3) and 'Maximize energy and material efficiency' (CBMP5). The resources that were used to fill in the protocol are the company's website, the case featured on the Ellen MacArthur Foundation and an article by Urbinati et al. (2017).

4.4 | Countries of Origin, Sizes and Phases

Table 4 presents the case characteristics of the 34 analyzed companies. The three largest groups of countries are the Netherlands (10 cases), the United States (10) and the United Kingdom (8). That those countries are represented well comes to no surprise since only English and Dutch information resources were used in the search for case studies. Therefore, this finding says nothing about the number of circular companies in a specific country. It was not a selection criterium. However, it is interesting to note which countries are represented in the sample and to what extent. Another point that needs to be noted here is that this variable only names the country of origin. A part of the companies in the sample are multinational and thus operate in multiple countries. Besides the different countries, Table 4 presents the number and percentage of small and large companies in the sample and start-ups and established companies. For both size and phase of the companies each variable is present in the sample for at least 40.0%. This means a good distribution between the different factors is present. The case numbers refer to the case companies, which can be viewed in Table 3 in Chapter 3 and Table 10 in Appendix D.

Table 4. Case characteristics (N=34)

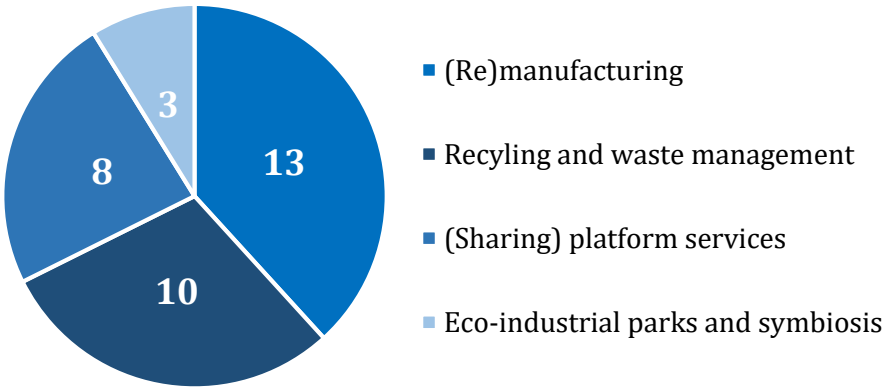
	Category	Percentage of N	Corresponding case numbers
Country	The Netherlands	29.4%	2, 4, 10, 11, 13, 18, 24, 25, 26, 27
	United States	29.4%	5, 7, 8, 9, 12, 16, 17, 19, 30, 34
	United Kingdom	23.5%	3, 6, 14, 22, 29, 31, 32, 33
	Denmark	5.9%	20, 21
	Italy	2.9%	1
	Israel	2.9%	28
	Luxembourg	2.9%	15
	Switzerland	2.9%	23

Size	Small	58.8%	4, 6, 11, 12, 13, 14, 15, 16, 18, 22, 24, 25, 26, 28, 29, 30, 31, 32, 33, 34
	Large	41.2%	1, 2, 3, 5, 7, 8, 9, 10, 17, 19, 20, 21, 23, 27
Phase	Start-up	44.1%	4, 11, 12, 13, 14, 15, 16, 24, 25, 26, 28, 30, 32, 33, 34
	Established	55.9%	1, 2, 3, 5, 6, 7, 8, 9, 10, 17, 18, 19, 20, 21, 22, 23, 27, 29, 31

4.5 | Industry Sectors

Even though the companies were placed in specific industries such as 'heavy machinery manufacturing' (Caterpillar) or 'IT disposal and asset retirement' (Cisco), it is possible to categorize them more generally. 13 companies (38.2%) are involved in (re)manufacturing, 10 (29.4%) in recycling and waste management, 8 (23.5%) offer (sharing) services in a platform and 3 (8.8%) are eco-industrial parks and symbiosis (Figure 9). The companies in the dataset are involved in all kinds of industries, which makes it an interesting set to analyze.

Figure 9. General division of industries (N=34)



An interesting point is that four companies (11.8%) are involved in carpet and flooring manufacturing. Aquafil produces nylon yarn used for carpet and cooperates with DSM Niaga. DSM Niaga, Desso and Interface are carpet producers and distributors.

In the category eco-industrial parks and symbiosis, there is Kalundborg Symbiosis (Kalundborg, Denmark), Park 20/20 (Hoofddorp, the Netherlands) and The Plant (Chicago, United States). These three cases differ from the other companies in this research, and can be better defined as communities or umbrella organizations. This fact resulted that in some parts of the protocol, variables could not be determined and were assigned unknown (-). An example is that it cannot be determined if the organizations are involved in 'Closed-loop production' (CBM2), because there

is no information available of all the companies in the umbrella organization. However, their activities are circular and extremely interesting and were therefore added to this research.

4.6 | Circular Business Models

26 CBMs were found in the literature and for every company analysis was done to determine which of the CBMs belonged to the business model of the company. A 27th option (called 'Others, namely …') was added to the case survey protocol where the researcher could add a CBM that was not mentioned in the literature. This last option was not used for any of the companies. The circular activities of companies could be translated into one or more CBMs in the existing list. Most of the companies were assigned to multiple CBMs. Table 5 presents all 26 CBMs from most assigned to least assigned and the corresponding case numbers.

Table 5. CBMs assigned (N=34)

	Percentage of N	Corresponding case numbers
Encourage sufficiency	82.4%	2, 3, 5, 6, 7, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33
Waste regeneration systems	58.8%	1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 17, 20, 21, 22, 24, 28, 29, 31, 32, 34
Extending product value	55.9%	3, 5, 7, 8, 10, 13, 16, 17, 19, 21, 22, 24, 25, 27, 28, 29, 31, 32, 33
Extending resource value	50.0%	1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 19, 21, 22, 24, 25, 27, 28
Product life extension	50.0%	3, 5, 7, 8, 10, 13, 16, 17, 19, 21, 22, 27, 28, 29, 31, 32, 33
Resource recovery	47.1%	1, 2, 3, 4, 5, 6, 9, 10, 11, 19, 21, 22, 24, 25, 27, 28
Take back management	47.1%	1, 2, 5, 7, 8, 9, 10, 11, 13, 16, 17, 19, 24, 27, 31, 32
Create value from waste	41.2%	1, 2, 3, 4, 5, 6, 11, 12, 13, 20, 22, 25, 34
Refurbishment	38.2%	3, 7, 8, 16, 17, 19, 21, 22, 24, 27, 29, 31, 32
Product recycling	35.3%	1, 2, 3, 4, 5, 10, 11, 17, 19, 22, 24, 29
Remanufacturing/next-life sales	35.3%	3, 5, 7, 8, 10, 17, 19, 22, 27, 29, 31, 32
Circular supplies	26.5%	1, 2, 4, 11, 12, 19, 20, 25, 28
Closed-loop production	23.5%	4, 5, 7, 10, 11, 12, 19, 28
Product transformation	23.5%	3, 4, 5, 8, 19, 27, 31, 32
Classic long-life model	20.6%	2, 7, 8, 10, 19, 27, 32
Cradle-to-cradle	17.6%	2, 4, 10, 12, 19, 30
Product as a service	14.7%	2, 10, 19, 24, 32
Sharing platforms	14.7%	14, 15, 16, 20, 26
Rematerialization	11.8%	1, 4, 5, 9
Co-product generation	8.8%	4, 20, 34
Service and function-based models	8.8%	18, 23, 27
Waste exchange (external)	8.8%	6, 20, 34
Waste exchange (internal)	8.8%	10, 11, 34

Industrial symbiosis	5.9%	20, 34
Upgrading	2.9%	13
Online waste exchange platform	0.0%	-

Some interesting points can be derived from these findings. The business model that was assigned most is 'Encourage sufficiency' (CBM7, 82.4%). If the activities of a company result in the fact that an end-user consumes less, than this factor is assigned. This goes from car sharing where the companies' activities result in less people buying their own car to designing products that last longer so that consumption decreases. It was found that the work of many of the companies result in less consumption by the end-users, so it can be seen as a core factor to the principles of the CE.

After that, with 58.8% of all cases, 'Waste regeneration systems' (CBM26) was assigned most. This is a generic model and is assigned when companies reuse or recycle waste. This means that all companies that do something directly with waste have this business model. The companies that were not assigned this variable are e.g. the online platforms. The principles of CE go beyond the processes of reusing and recycling, but that does not mean those processes are not seen a lot in the case companies this finding proves.

The business models 'Extending product value' (CBM8, 55.9%), 'Extending resource value' (CBM9, 50.0%) and 'Product life extension' (CBM13, 50.0%) were assigned to (more than) half of the companies. Whereas the first two business models focus on the take-back of used products and (re)use of the products, components of products or materials, 'Product life extension' goes a step further by thinking about the design of the product to extend the life of a product. It was found that even though there is a distinguished difference in the meanings of those business models, in practice these activities are closely related and often combined. All companies that were assigned 'Product life extension' business model were also assigned with 'Extending product value'.

None of the companies had the business model 'Online waste exchange platform' (CBM11). This business model is when a company brings together users and producers of waste. It is possible that it is a coincidence that such a company is not present in the sample, but it can also mean that of all possible CE activities this particular model is not frequently seen and a niche market. The business model 'Upgrading' (CBM23) was only assigned to Fairphone, because of the upgrading possibility in their modular phones. There is one business models that could only be assigned to two out of the 34 cases. 'Industrial symbiosis' (CBM10) was only assigned to the eco-industrial park Kalundborg Symbiosis and the vertical farm and food incubator The Plant. This variable was twice accompanied with 'Co-product generation' (CBM4). Co-production generation means that a

company is able to create multiple revenues by selling co-products based on recycled waste, process residues or byproducts. For example for The Plant, coffee chaff from the coffee business goes to the production of vegetables.

The cradle-to-cradle business model (CBM5) was assigned to six companies. The company's certification could be retrieved from the website www.c2ccertified.org. Even though the company Aquafil does not have this certification, their nylon yarn is used in the products of DSM Niaga and Egetaepper, a Danish carpet manufacturer that was not included in case sample. Both companies are Cradle to Cradle™ Certified.

Auping was assigned the 'Create value from waste' (CBM6) business model, even though they do not recycle the products themselves. They do have a close collaboration with a recycler, where Auping takes the mattresses back and sends it to the recycler. Auping was also assigned 'Product as a service' (CBM12), as they started a pilot with Landal GreenParks. However, this is only a small part of their business. Cisco, the networking equipment manufacturer, is investigating a product as a service model at the moment. This company was not assigned the 'Product as a service' (CBM12) model, but a note should be made here that they are considering it.

Another interesting point to address is to compare the amount of CBMs that were assigned to the companies in total. The carpet manufacturers Interface, Desso and DSM Niaga were assigned 15, 14 and 10 of the 26 CBMs respectively. These 'scores' are amongst the highest in the dataset. Braiform, the garment hanger reuse company, was assigned 13 of the 26 CBMs. It was found that these companies are involved in a lot of different activities: they recycle, remanufacture, encourage sufficiency, etc. A suggestion to this phenomenon is that those industries seem to be quite mature, because the companies are able to integrate many different aspects of the CE. On the other side of this spectrum, there are the companies Fat Lama, FLOOW2, Greenwheels, Mobility Carsharing and Replenish that were only assigned two CBMs. Most of those companies are online sharing platforms (CBM21) or service or function-based models (CBM20) and encourage sufficiency (CBM7). These companies have clear principles that initially help the economy to be transferred to a CE. No information is available about the success of the companies in the dataset, therefore nothing can be concluded on what it means how many CBMs a company can be assigned. However, further research in this can be interesting next steps in research.

4.7 | Limitations and Challenges

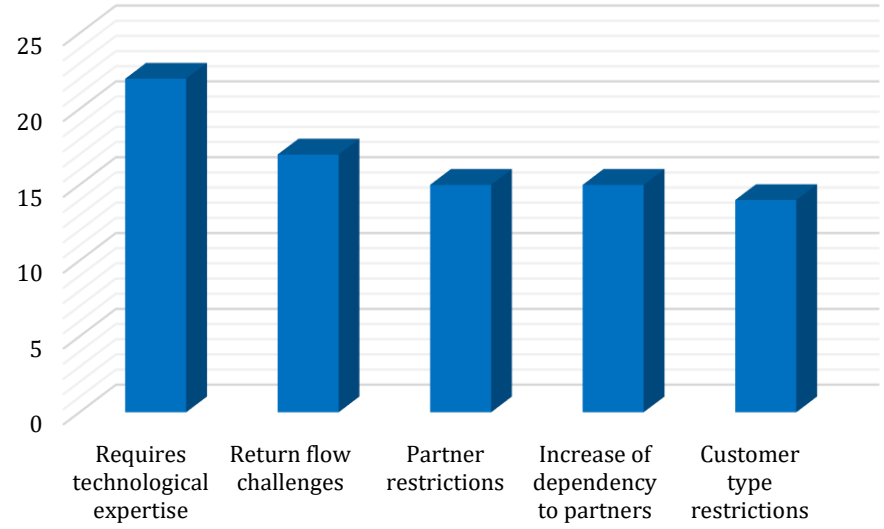
This section focuses on the limitations and challenges that companies (may) experience. Most of the time the problems were not explicitly mentioned in the case materials. However, it was to

some extent still possible to determine if a company experiences a hurdle or not. As an example, fashion vulnerability focuses on consumer markets where aesthetic attributes play an important role. This may form a hurdle for the jeans leasing company MUD jeans, but one can imagine that this is not one of the fears of the re-usable paper manufacturer REEP Technologies. Moreover, capital tied up and operational risk are problems that occur when ownership of a product is shifted from the customer to the company, as happens in product as a service business models. With logical thinking many of the limitations and challenges were able to be assigned or not. Table 6 presents the 18 problems that were found in the literature. Figure 10 presents the five most assigned limitations. In the protocol there was a 19th option to mention limitations, challenges or problems that were not yet addressed. There was one company with a not mentioned problem, that will be later explained in this section.

Table 6. Limitations and challenges assigned (N=34)

	Percentage of N	Corresponding case numbers
Requires technological expertise	64.7%	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 13, 17, 19, 20, 21, 22, 24, 28, 29, 30, 31, 34
Return flow challenges	50.0%	1, 5, 7, 8, 9, 10, 11, 13, 16, 17, 19, 22, 24, 27, 29, 31, 32
Partner restrictions	44.1%	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 20, 22, 25, 31, 34
Increase of dependency to partners	44.1%	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 20, 22, 25, 31, 34
Customer type restrictions	41.2%	2, 4, 7, 12, 13, 16, 17, 22, 24, 26, 28, 32, 33
Product category restrictions	32.4%	3, 6, 7, 9, 13, 17, 20, 22, 29, 30, 31
Operational risk	26.5%	7, 10, 16, 18, 19, 23, 24, 27, 32
Higher risks for CBM	26.5%	7, 8, 10, 11, 17, 19, 24, 27, 33
Cultural barriers	23.5%	12, 14, 18, 23, 25, 26, 28, 32
Capital tied up	20.6%	16, 18, 19, 23, 24, 27, 32
Fashion vulnerability	14.7%	11, 13, 16, 24, 32
Mutual benefits for all partners	14.7%	2, 11, 20, 25, 34
Economic barriers	11.8%	1, 20, 21, 29
Confidentiality for individual firms	11.8%	15, 20, 25, 34
Organizational barriers	5.9%	15, 25
Risk of cannibalization	2.9%	2
Lack of supporting regulation	2.9%	4
No problem owner	0.0%	-

Figure 10. Five most assigned limitations and challenges (N=34)



The limitation that was found most is 'Requires technological expertise' (LIM16). To make products more circular in the first place or to design the remanufacturing or refurbishment processes of a company, knowledge is needed. Knowledge about the materials and the products, and knowledge on the technology to do so.

The second most assigned limitation is 'Return flow challenges' (LIM17). This is applicable for companies that offer take back management in order to recycle or repair a product. Reverse logistics is needed and a company may experience trouble with the predictability of the return flow. A situation may occur that a company offering maintenance for its products receives many products sent back at the same time. This results in difficulties in capacity planning. It was found that many of the companies in the sample are involved with take back management.

The third and fourth most assigned limitations are 'Partner restrictions' (LIM14) and 'Increase of dependency to partners' (LIM8) respectively. The limitations were both added to the list of challenges, but in the end could better be combined. 'Partner restrictions' includes all problems that companies may experience when they collaborate with other companies or organizations. CE companies often work together with their suppliers or e.g. transport companies that help with their reverse logistics. 44.1% of the cases was found to be working tightly together with partners.

The last limitation to mention that was assigned often to companies is 'Customer type restrictions' (LIM4) with 41.2%. This includes companies that offer for example remanufactured or refurbished products. Not all customers are environmentally interested to a level that they have no problems paying more for a product or accepting a product that may be lower in quality due

to its refurbishment. Even if companies can prove that the remanufacturing or refurbishment does not change the quality of the product, there are customers that still favor the 'new' product. In an interview that was found with a product manager of Caterpillar it was named explicitly: "People think [the remanufactured product] means washed, painted, repaired, second hand and so on. It's a challenge to convince and educate the consumer that they're getting the same performance at 50-60% of the cost of new" (Urbinati et al., 2017, p. 495).

The limitation 'No problem owner' (LIM11) was assigned to none of the companies. This was found to be more of a global problem that the whole CE experiences towards the transition than that it is a problem a single company can experience. This problem states that a single company does not focus on large global issues. A company's first priorities lie in e.g. ensuring the costs of the company equals at least the total income and not in stating it is the problem owner of the depletion of natural resources. It can be argued that this is not a problem one would name in a list of 'problems CE companies can encounter'. However, it will be shown later that many companies 'Adopt a stewardship role' (which is a CBMP) in order to make their customers aware of sustainability and CE issues.

The second and third least assigned limitations are 'Risk of cannibalization' (LIM18) and 'Lack of supporting regulation' (LIM9). The first one means that a company produces new longer-lasting products that result in a decrease of sales of their older, shorter-lasting products. This was only assigned to bed and mattress manufacturer Auping. The only company assigned to 'Lack of supporting regulation' is Black Bear Carbon. In an article it was said that "assumptions of the current regulation are still based on the old linear thinking and tries to protect society from the evils of waste" (Circle Economy, 2018b). This does not mean that all other companies experience no trouble with regulation, but it was only found explicitly in the case study material of Black Bear Carbon.

A different problem that was found when analyzing the companies concerns Ecovative. This company produces fully compostable packaging products. After the use of the packaging, the products can be composted at home. If the packaging is thrown away in a normal manner, nothing of the companies' CE efforts is left. Therefore, this company highly depends on the help of the customer, an involvement and determination of the end-user is required. This is not an aspect of 'customer type restrictions', but can be better defined as 'increase dependency to customers'. This problem is slightly different than 'customer type restrictions' (LIM4).

4.8 | Circular Business Model Patterns

The last variable in the protocol, and most important one regarding the topic of this thesis, is the CBMP. The number of cases that were assigned to the different patterns and the percentages are given in Table 7. Besides the 11 CBMPs, the protocol offered a 12th option for other CBMPs that were seen in the companies. This option generated two inputs and will be elaborated on later in this section.

Table 7. CBMPs assigned (N=34)

	Percentage of N	Corresponding case numbers
Adopt a stewardship role	88.2%	1, 2, 4, 5, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31, 32, 33, 34
Recycling/create value from waste	52.9%	1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 17, 20, 22, 24, 25, 29, 34
Refurbishment and remanufacturing	41.2%	3, 5, 7, 8, 10, 16, 17, 19, 21, 22, 27, 29, 31, 32
Access and performance model	32.4%	2, 10, 14, 15, 18, 19, 23, 24, 26, 27, 32
Repair and maintenance	29.4%	2, 5, 7, 13, 16, 21, 24, 27, 29, 31
Reuse and redistribution	26.5%	5, 7, 8, 10, 16, 19, 28, 32, 33
Maximize material and energy efficiency	17.6%	8, 11, 19, 20, 25, 30
Substitute with renewable and natural processes	14.7%	10, 11, 19, 20, 25
Organic feedstock	11.8%	6, 12, 20, 34
Cascading and repurposing	8.8%	12, 20, 30
Industrial symbiosis	5.9%	20, 34

The most assigned pattern is 'Adopt a stewardship role' (CBMP2). 88.2% of all cases were assigned with this pattern. This is a broad pattern and was assigned to all companies that state on e.g. their website that their business is doing in terms of sustainability and CE. Examples are the provision of sustainability reports or a sustainability or CE explanation on their website. The second most assigned option is 'Recycling/create value from waste' (CBMP7) and the third 'Refurbishment and remanufacturing' (CBMP8). More than half of the companies (52.9%) create something out of their own waste or waste from others. Refurbishment is taking used products and return them to the quality level they had.

As mentioned earlier, two other patterns were seen. As for the company GameStop, but also for other companies, reverse logistics takes an important role for circular companies. This process has not been named explicitly in the list provided from literature, but can be considered a CE-related pattern. The other pattern concerns the company Replenish, which marketed a new product that tackled a large problem (See Section 4.3). They produce reusable packaging bottles

that are designed to mix liquid concentrate refill pods with water. The refills pods are sent to the customer and the customer then adds warm water to create the cleaning products. This could be called 'circular innovation' or 'circular solution'.

4.9 | Hierarchical Clustering in SPSS

It will be examined if there are clustering relationships between the CBMPs and the CBMs and between the CBMPs and the limitations and challenges. This can lead to answers to questions as: are certain limitations and challenges of circular companies related to certain CBMPs? This section consists of two subsections that will each show a dendrogram of the cluster analysis done in SPSS. As was explained in Section 3.7, statistical significance is hard to gain with a small sample size (n) for this analysis. Therefore, this can be seen as an exploratory and extra analysis on the dataset.

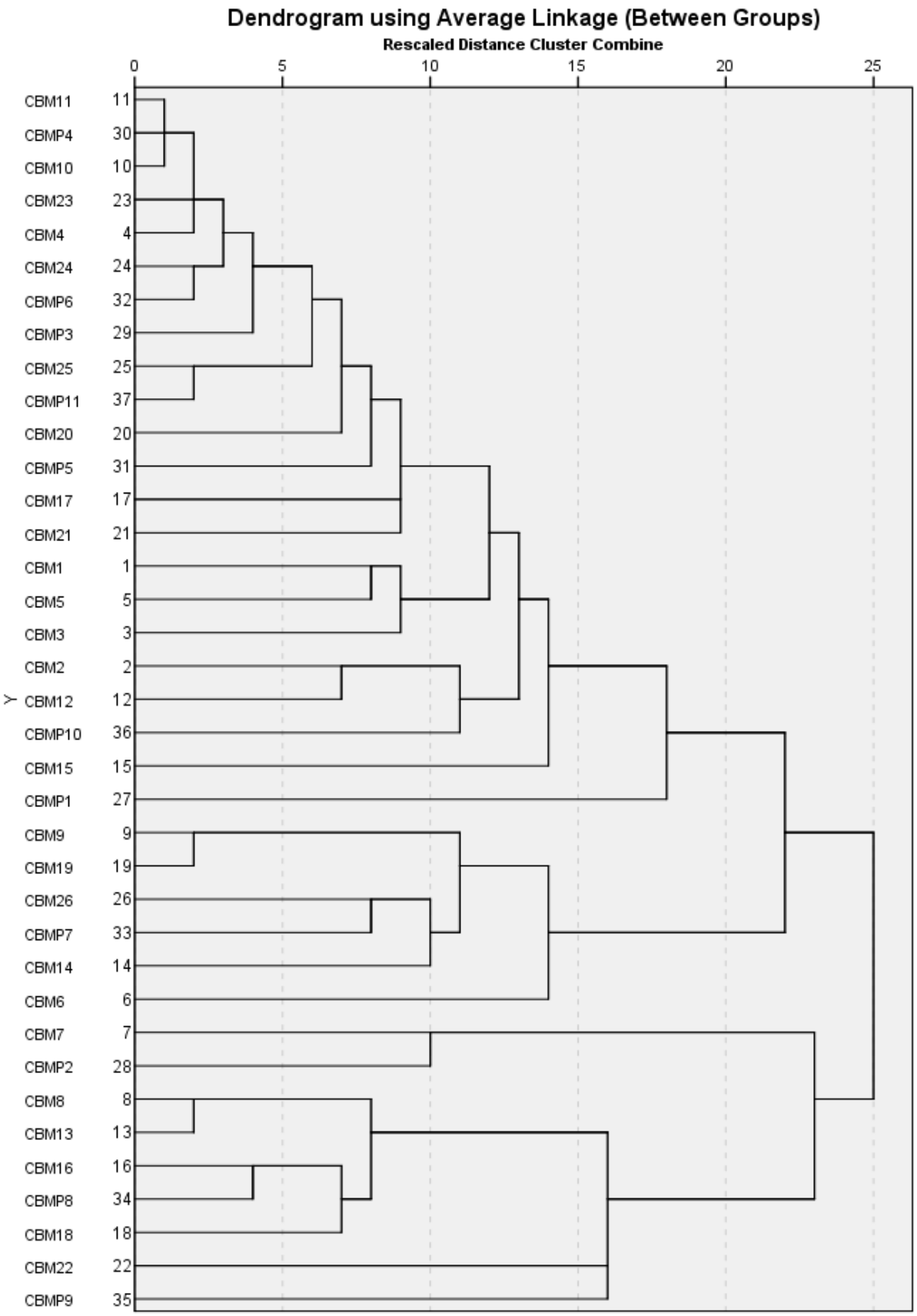
4.9.1 | Clustering the Patterns with the Business Models

In Figure 11 the dendrogram is shown. The CBMs and CBPMs are labelled with the same numbers as shown in the protocol in Appendix B. This means that CBM1 corresponds to 'Circular supplies', CBMP1 to 'Access and performance model', etc.

The closest relations present in the dendrogram will be discussed next. The chi-square test (χ^2) results will be given, where high statistics prove the assumption that there is an association and that it is not due to chance. The probability and the degree of freedom will be added to that statistic.

All variables in the CBM and CBMP group were added. Reading the dendrogram, the closer the variables are grouped, the more similar they are. Starting with reading the diagram from above, CBM11, CBMP4 and CBMP10 are in this diagram the closest to each other. These variables are 'Online waste exchange platform', 'Industrial symbiosis' (the pattern) and 'Industrial symbiosis' (the business model) respectively. Since both variables mean the same, it is logical that they are positioned next to each other. The online waste exchange platform was assigned to none of the companies. However, to recall Section 3.7, cluster analysis will always create clusters. Even when there is no structure in the data, which in this example in all probability is the case. A possible explanation to why it was clustered there is because the industrial symbiosis variables were not assigned to many companies and 'online waste exchange platform' to none. Close to this cluster is CBM23 and CBM4, which correspond to 'Upgrading' and 'Co-product generation' respectively. These variables were also not assigned to many companies (8.8% and 2.9% of the companies respectively).

Figure 11. Dendrogram of all CBM and CBMP variables



Going further down the dendrogram, a cluster between CBM25 (Waste exchange (internal)) and CBMP11 (Substitute with renewable and natural processes) is shown ($\chi^2(1)=12.8$, p=<0.000). Companies associated with one seem to be associated with the other as well. 'Extending resource value' (CBM9) shows a close cluster with 'Resource recovery' (CBM19) ($\chi^2(1)=28.2$, p=<0.000). The latter business model can be viewed as a part of the first business model.

Another cluster to mention is the one between CBM7 (Encourage efficiency) and CBMP2 (Adopt a stewardship role). These two concepts are closely related, which is now confirmed with this analysis. Encourage efficiency means when the activities of a company result in reducing the end-user consumption and the CBMP entails companies that adopt a stewardship role in e.g. environment protection and circularity promotion.

Another close relation is shown between CBM8 (Extending product value) and CBM13 (Product life extension) ($\chi^2(1)=24.8$ p=<0.000). The first CBM is when a company takes back products and uses that or components in a way to exploit the residual product value. The second CBM is for companies who design long-lasting products, which often goes hand in hand with extending product value.
The last cluster to mention is the one between CBM16 (Remanufacturing/next-life sales) and CBMP8 (Refurbishment and remanufacturing), which may come as no surprise as remanufacturing is represented in both concepts ($\chi^2(1)=24.7$, p=<0.000).

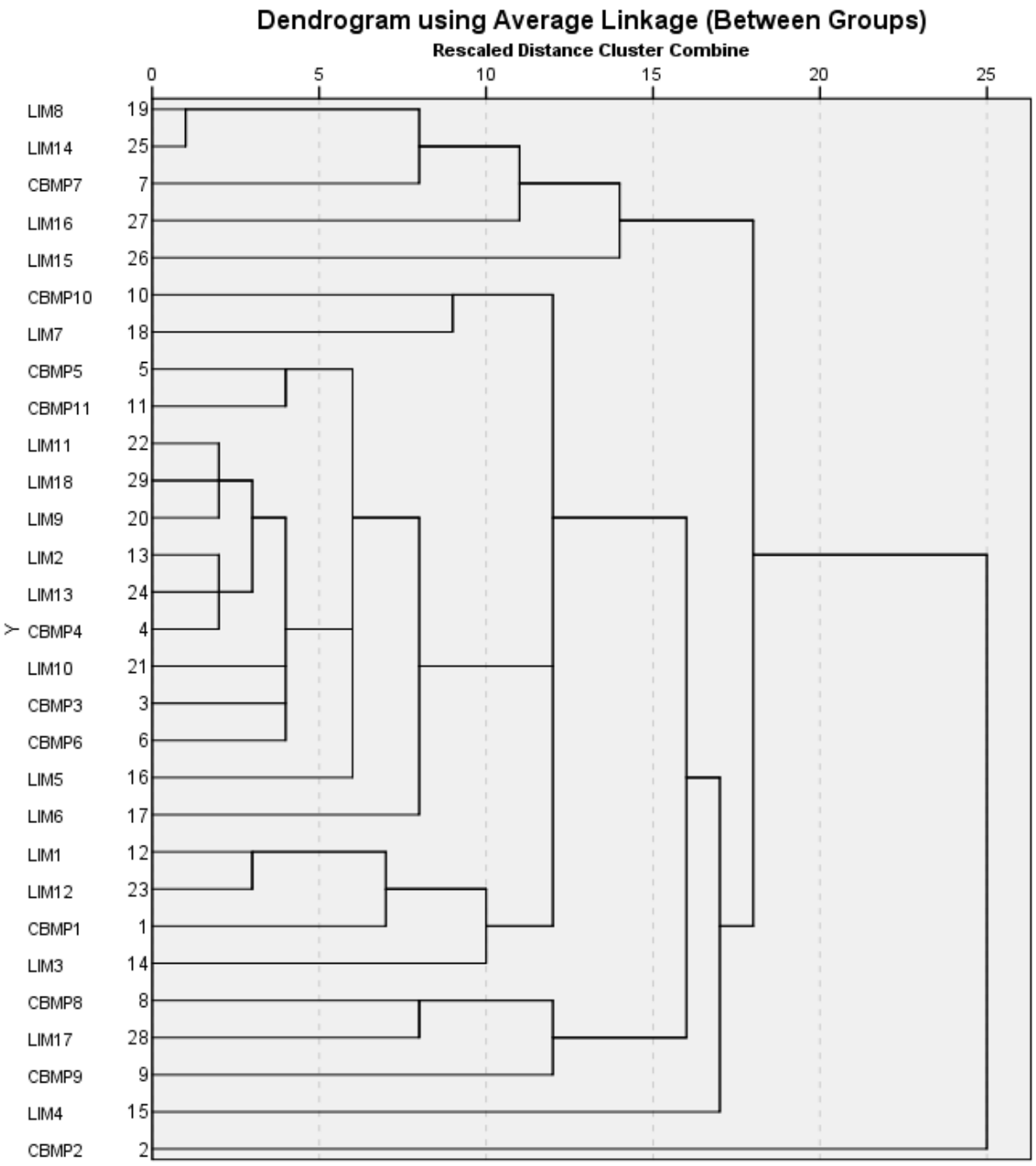
4.9.2 | Clustering the Patterns with the Limitations and Challenges

Figure 12 presents all the limitations and challenges and the CBMPs. The labelling of the limitations and the CBMPs is shown in Appendix B, where CBMP1 corresponds to 'Access and performance model' and LIM1 to 'Capital tied up', etc.

Starting again reading the dendrogram from above, LIM8 (Increase of dependency to partners) and LIM14 (Partner restrictions) are closely related ($\chi^2(1)=34.0$, p=<0.000). That these two limitations could in the end better be combined was something already referred to earlier in this chapter (Section 4.7). All companies with tight partnerships were assigned both of these challenges.

A strong relation is shown between 'Maximize material and energy efficiency' (CBMP5) and 'Substitute with renewable and natural processes' (CBMP11) ($\chi^2(1)=15.7$, p=<0.000). These patterns contain processes and organizational changes that may be often combined in CE implementation cases.

Figure 12. Dendrogram of all limitations and CBMP variables



LIM11 (No problem owner), LIM18 (Risk of cannibalization) and LIM9 (Lack of supporting regulation) were clustered together. However, these limitations were only assigned to 0, 1 and 1 company respectively. It is suggested that those two were found to be related in this analysis due to the fact that they were not assigned (much). All variables will be clustered, even when there is no relation. The concepts do not seem to have a particular relation. This phenomenon is also the

case for the cluster of LIM2 (Confidentiality for individual firms), LIM13 (Organizational barriers) and CBMP4 (Industrial symbiosis).

The cluster of LIM1 (Capital tied up) and LIM12 (Operational risk) ($\chi^2(1)=24.5$, p=<0.000) can be explained by the fact that those problems are often experienced together in service models. Seven companies (Furnishare, Greenwheels, Interface, Mobility Carsharing, MUD Jeans, Philips Lighting and Rype Office) were assigned both limitations. Capital tied up means that when ownership of the product transfers from the customer to the producer, than so does the financial risk. The liability and operational risk of the customer transfers also to the firm in a service model, which explains the second limitation. In the dendrogram next to these two limitations, CBMP1 (Access and performance model) is shown ($\chi^2(1)=11.5$, p=<0.000). This confirms that these limitations are related to this pattern.

It is interesting to note that the closest relations seen in Figure 12 are either two limitations or two CBMPs. No very direct relationships are formed with one or more limitations and/or CBMPs, apart from the access and performance model pattern explained in the paragraph above. Therefore, not a lot regarding the close relationships between limitations and patterns can be concluded.

4.10 | Results of Chi-Square Tests in SPSS

For the clusters found in the hierarchical clustering method, the χ^2 statistics were calculated and shown. The χ^2 statistics for every combination of a CBMP with a CBM and CBMP with a limitation were calculated and studied. For every CBMP, the most striking results will be elaborated on. These are mostly the statistics with a high value, as that entails associations that are not due to chance.

For CBMP1 (Access and performance model), the limitations 'Capital tied up' and 'Operational risk' gave the highest $\chi^2(1)$-values (for both: $\chi^2(1)=11.5$, p=0.001). This relation has already been elaborated on in Section 4.9.2. Another limitation that gave a high result was 'Product category restrictions' ($\chi^2(1)=8.3$, p=0.004). Not all products are easily transferred in an access and performance model. High statistic values for CBMs were 'Product as a service' ($\chi^2(1)=12.3$, p=<0.000) and 'Service and function-based models' ($\chi^2(1)=6.9$, p=0.009).

For CBMP2 (Adopt a stewardship role) no high (≥5.0) $\chi^2(1)$ statistics were shown. Statistics on CBMP3 (Cascading and repurposing) and CBMP4 (Industrial symbiosis) did not lead to new insights that have not been mentioned before in Section 4.9.1 and 4.9.2.

CBMP5 (Maximize material and energy efficiency) shows a relation with the CBM 'Circular supplies' ($\chi^2(1)=5.7$, $p=0.017$), which can be explained by that circular supplies are needed to enhance material efficiency. Circular supplies can be fully recycled, which is efficient. For CBMP6 (Organic feedstock) no significant results were found.

CBMP7 (Recycling/create value from waste) shows a strong relation with 'Partner restrictions' ($\chi^2(1)=12.3$, $p=<0.000$). In the case companies it was shown that often collaborations exist between a company and a third party that recycles its products. This increased collaborative behavior might lead to limitations in implementing a CBM for a company. CBMs highly correlated with this pattern are 'Extending resource value' ($\chi^2(1)=10.2$, $p=0.001$) and 'Product recycling' ($\chi^2(1)=14.7$, $p=<0.000$).

An interesting correlation shown in CBMP8 (Refurbishment and remanufacturing) is the one with the limitation 'Return flow challenges' ($\chi^2(1)=10.6$, $p=0.001$). If a company wants to refurbish or remanufacture used products, take-back management is needed and this can result in problems with the return flow.

The patterns 'Repair and maintenance' (CBMP9) and 'Reuse and distribution' (CBMP10) showed no insightful chi-square test results. CBMP11 (Substitute with renewable and natural processes) showed relations with the CBMs 'Closed-loop production' ($\chi^2(1)=9.9$, $p=0.002$) and 'Waste exchange (internal)' ($\chi^2(1)=12.8$, $p=<0.000$).

4.11 | Semi-Structured Interviews with Academic Researchers

After the case survey was executed, semi-structured interviews were held with two academic researchers both in the field of researching CBMs. In this interview, amongst others, the findings of the case survey were discussed. The set-up of these interviews is shown in Appendix E.

During one of the two interviews it was pointed out that "companies do not like reducing, in the current system you have to grow all the time". The interviewee pointed out that, in his opinion, the CE is gaining more attention because companies see new ways of creating profit. The current economy is one where a company constantly has to grow in order to survive. Circular principles such as closing the loop provide new ways to do business and thus can be used to create new revenues. However, it is only circular if those new principles happen in a certain way. As an example, if a company goes from a normal business model to a service model, but in end due to

extra transport the CO_2 emissions increase, than the company may have changed to a CBM but does not decrease its environmental impact.

The pay-per-use models and service models are present in many companies. Companies see that it may be a good next move for them. This trend is confirmed by the companies Auping and Cisco; the first is currently doing a pilot examining the service model and the second is investigating it. An interviewee added to this point that servitization is upcoming because the world is getting more digital and connected, and people seem to be slightly less interested in the ownership of products.

In order to make the current economy more circular, is it good to focus on companies that have all the same goal of making profit? Another point of view is to look at governments that have power in changing laws and regulations. However, also governments feel pressure from the economy in the same way companies do. One researcher pointed out that in a future a CE is possible, but that it still needs huge steps before we are there. Right now it is very important to create awareness and "critical mass" about the opportunities that the CE brings. Besides, it is also important that the companies and the public should be aware that not only things as transfer of ownership of products is needed, but that businesses should also focus on decreasing their impact on the environment in order to solve the problems the world is dealing with.

4.12 | Answers to Sub Research Questions 3 and 4

With the results of this chapter, the two last sub research questions can be answered.

The third sub research question was: *Which circular business models, circular business model patterns and implementation barriers can be identified in business practice?* The research-specific part of the case survey was dedicated to the three variable categories (CBMs, CBMPs and the limitations). Most of the companies in the dataset are involved with either (re)manufacturing (38.2%) or recycling and waste management (29.4%). Almost all of the variables were assigned to at least one of the case companies in the dataset, where most of them were assigned to more than one. By far the most assigned CBM was 'Encourage efficiency' and after that 'Waste generation systems'. Many companies in the sample did something with recycling. The CBM 'Online waste exchange platform' was not assigned to any of the companies, but it was explained that this is probably due to the fact that this business model is unique and small compared to others. It was also noted that some companies could only be assigned one or two CBMs, whereas others were assigned almost half or more than half of them. The limitation for companies seen most is 'Requires technological expertise', followed by 'Return flow challenges', 'Partner

restrictions' and 'Customer restrictions' respectively. As was found in the literature, CBMs require more integration between partners and consumers. This is confirmed by that these limitations are present often in those companies. The limitation 'No problem owner' was also not assigned to any of the companies, but it was elaborated on that this is a broader CE implementation problem that cannot be accounted to single companies. All CBMPs were at least assigned to 5.9% of the case sample. The most assigned CBMPs are 'Adopt a stewardship role', 'Recycling/create value from waste' and 'Refurbishment and remanufacturing' respectively. Besides, some other variables were found. For the list of patterns, the case sample provided two new ones: 'Reverse logistics' and 'Circular solution'. Moreover, a different type of limitation was found that can be described as 'Increase dependency to consumers'. It can be concluded that the variables found in literature are identified in business practice.

Afterwards the relations between the variables were studied, which constitutes the second part of the sub research question. This was done via hierarchical cluster analysis and additional analysis with chi-square tests. It can be concluded that small and bigger relations exist between CBMPs and CBMs and CBMPs with limitations. There is e.g. CBM 'Encourage efficiency' and CBMP 'Adopt a stewardship role' that were correlated. The problems 'Capital tied up' and 'Operational risk' showed a relation with the pattern 'Access and performance model'. The pattern 'Refurbishment and remanufacturing' was correlated with 'Return flow challenges'. It can be concluded that relations exist between the variables. However, some relations were not very strong and sometimes due to the fact that in cluster analysis everything has to be places somewhere, regardless of the missing connection.

The fourth sub research question was: *How can circular business model patterns stimulate more widely adoption of circular business models and how can this contribute to a transition to a more circular economy?* CE is not something a single actor can reach on its own. It is, compared to the linear economy, a system where much more collaboration is needed. This was both said in the interviews as well as found in literature (Oghazi & Mostaghel, 2018). Better understanding of CBMPs can enhance the transition to a more circular economy. Gassmann et al. (2014) found that many cases of BMI consist of a recombination of existing BMPs. Managers can use these patterns to generate a new business model systematically or adapt an existing one. Innovative business models can be created by the rearrangement of existing CBMPs. Patterns can be used as a source of information for new and existing companies. Moreover, Echterfeld et al. (2015) states that BMPs form a valuable approach to describe and understand logics of new, unknown markets. With the arrival of the CE there are not necessarily new markets, but existing business models in many markets are changing. This point was confirmed in an interview where the interviewee stated that

knowledge on CBMs and CBMPs can be of extremely high value for the CE transition. To quote him: “Using the business model frameworks is a good way to talk with companies about innovation”. Because of CE, innovation in business models is needed and patterns can help this innovation to the right direction. The interviewee thinks that the field of CBMPs is interesting and allows companies and scholars to have concrete discussions about difficult issues. So far this paragraph stresses the importance of CBMP knowledge for the transition to a more circular economy. CBMPs can be valuable tools for companies. The first part of this sub research question asks how these CBMPs can become more widely adopted. An interviewee said that it is important to create awareness and critical mass for CE and its related concepts. There is still a long way to go, but this can be one of the steps to move forward.

Chapter 5 | Discussion

The goal of this chapter is to elaborate on the entire research and go through what the results really mean. The limitations are presented in Section 5.1, and are subdivided into language and search barriers that were present in the research, general case survey limitations, sourcing and selection limitations, coding limitations, sample size limitations, reliability limitations and limitations regarding the conducted interviews. Section 5.2 elaborates on the quality of the research and its contribution. Section 5.3 is dedicated to the relevance of the study to the broader CE transition.

5.1 | Limitations

It is important to know and understand the limitations of the research in order to properly discuss and draw conclusions from the results. The limitations are divided into seven different parts in this section.

5.1.1 | Language and Search Barriers in the Literature Review

The goal of the literature review was to present a comprehensive review of the relevant and recent academic work on business models and the circular economy. However, it is highly probable that important information was not found or was not available to the researcher due to e.g. language restrictions. An example here is China, because according to scholars it was one of the first countries that took action regarding the implementation of CE. Besides, the researcher could have missed out on relevant concepts that were not included in the search for literature.

During the search for CBMs and CBMPs, limitations and challenges for CBE implementation were found. As part of this research examines what is needed for a transition to a more circular economy, these papers on CE issues were found to be extremely relevant. Three papers that described CE related problems for companies were combined to form a list of problems, which is mostly referred to in this thesis as the list of 'challenges and limitations'. However, it is highly probable that some implementation issues have been missed out. One of the reasons is that Linder & Williander (2017) stated that their research focused on CBMs in remanufacturing and reuse, but many more forms of CBMs exist. The combined lists of Linder & Williander (2017) and Oghazi & Mostaghel (2018) consisted of duplicates and the researcher did a suggestion in regrouping some of the problems. It is possible that this was not done correctly. Later, in Chapter 4, it was found that LIM10 'Partner restrictions' and LIM16 'Increase of dependency to partners' could better be merged. Another point here is that the 'no problem owner' issue of Roos (2014) was

included in the list, but is not an issue that a single company really can experience and can be better seen as a more global problem that explains partly why full CE transition is hard. The result of this was that this issue was not assigned to one of the companies.

The list of patterns from literature was started with six proposed patterns from Lüdeke-Freund et al. (2018) in which the authors state that their approach is not complete. To expand this list of existing patterns, business model strategies and business model archetypes were added. These two categories could be, according to the researcher, also be seen as a 'business model building block', which is part of the definition of a BMP defined by Osterwalder & Pigneur (2010). These different findings were selected and grouped together by the researcher, which due to bias or misinterpretation can contain mistakes. This regrouping formed the main finding of the literature review: 11 CBMPs.

In this research a distinction has been made between business models and business model patterns. Lüdeke-Freund et al. (2018) proposed 26 CBMs and these were directly used for the case survey analysis, but as an example, the business model 'industrial symbiosis' (CBM10) was also present in the list of CBMPs as CBMP8. Besides, as another example, the business model 'circular supplies' (CBM1) constitutes not the whole business model of a company, but is only a part of it. It can be may be better seen as a 'building block', which was part of the BMP definition of Osterwalder & Pigneur (2010). Therefore, it is suggested that a well-understood distinction between the definitions of circular business models and circular business model patterns should be created. If the current list of CBMPs is revised and/or extended, a CBMP taxonomy may be established. Here, the taxonomy of Remane et al. (2017) can serve as a template or example on how to do this. A taxonomy could increase the understanding of CBMPs.

5.1.2 | General Case Survey Limitations

The case survey methodology itself has general limitations. These were introduced in Chapter 3 and are now shortly recalled. First, there is always a limited amount of available case studies that can be included in the case survey. Second, a secondary investigator does not select the cases. In this research, there was not a secondary investigator so also the coding was executed by only one researcher, which is an extra limitation. Therefore, it will be hard to achieve theoretical and statistical generalization. Another drawback is that reports of case studies are limited in space. It is therefore possible that the information that is needed for the case survey is not present in the report. Another important limitation is that the quality of the case survey can never exceed the quality of the single case studies that it studies. The last limitation found in literature is one regarding coding: complex phenomena can be hard to code.

5.1.3 | Case Study Sourcing and Selection

This paragraph continues with limitations on the case survey limitations that were specific for this research. The main aim of the case study sourcing was to find as many circular companies as possible to study the variables in a business practice. This list is not comprehensive and probably not a good representation of reality. Circular companies are missed out, 'popular' companies will be found more easily, etc. One of the criteria that was set was that companies that do not operate circular also should be included, but if a company does not mention that on its website, it becomes very hard to find it. Moreover, companies were not selected based on their (monetary) performance. However, successful stories are probably more available than stories about companies that tried to be circular but failed or went bankrupt. The 34 selected companies could therefore represent a wrong impression of reality that was too positive. Another point is that the selection was partly based on how much information there was found. A second researcher could select a totally different case sample that could have led to totally different results. Umbrella organizations such as Kalundborg Symbiosis were added to the case sample, which consists of multiple companies. The limitation formed here is that those organizations are more difficult to compare with other single companies in the dataset.

5.1.4 | Coding of the Cases

In the data collection the coding of the case studies was performed. Sometimes it was hard to assign either 0 or 1, as there was no value situated in between. Contrary, a factor in between would also be hard to assign with the limited information the researcher had. The information used to assess each company was from academic journals and online websites. No justification or validation was asked from the companies and the information was assumed to be right. Besides, information provided by a company itself on its website may create a very opportunistic impression on what it is doing. This again could lead to too optimistic results. If this research was executed with e.g. interviews with the companies, than more values besides 0 and 1 could be used and assigned. But as a side note, another methodology brings its own limitations as well.

5.1.5 | Sample Size

Due to time limitations it was possible to only study and analyze 34 cases. This brings limitations for the statistics that were performed as well. For a small sample size it is harder to show statistical significance (Hair et al., 2014). In literature no minimum number of cases was found for hierarchical cluster analysis was found, but scholars agree that a moderate or large sample size provide significant results. The cluster analysis was chosen for this research because it provides a simple, yet comprehensive overview of the clustering solutions. Also no minimum of cases is

needed for chi-square tests, but also for this statistic counts the more the merrier. It should be noted that the results from this thesis therefore cannot be generalized.

5.1.6 | Reliability

The case survey has been conducted by one researcher, whereas most case survey methodologies add a second investigator to the protocol to establish interrater reliability. Instead of a second investigator case authors have been contacted to comment on the case study findings. Again due to time limitations only one case author was contacted. However, the case author agreed to a very large extent with the researchers' work and was only able to add small details to the company findings. To increase reliability future research could add secondary researchers and/or more involvement of case study authors and case companies.

5.1.7 | Semi-Structured Interviews

Only two interviews were held and these interviews were conducted with academic researchers in the field of CBMs. They were chosen because they work for the same university and were therefore easy to contact. The focus of this thesis is the business practice, which is something experts in the practical field could maybe say more about. Accessibility of the interviewees and time restrictions formed the main reasons for the used interview approach.

5.2 | Quality of the Research and Contributions

Bearing in mind the limitations that were previously mentioned, this section goes further on what the results actually mean. The knowledge gap was the lack of a comprehensive list of CBMPs. This thesis forms a contribution to the knowledge base on CE, especially on CBMPs. The literature review is extensive and incorporated different business model and CE related topics. Not only CE was studied, but also BMPs. Clusters and relations between variables have been presented and knowledge has been shared that was gained from the interviews. Implementation barriers can be related to certain CBMPs as an example. This work aimed to make this list of CBMPs larger by combining literature with practical work. The contribution to the literature can be therefore defined as the more comprehensive list of patterns. This list of CBMPs also adds to the literature on business models and BMPs. The patterns identified in this work are e.g. not incorporated in the pattern database of Remane et al. (2017), so this database could be enlarged with patterns from the CE field. It might be interesting to study this patterns in BMI cases, where it can be determined to what extent these patterns can be helpful for managers. The list of implementation barriers is a merging of multiple papers on this issue, which forms also a contribution the literature. A problem defined as 'increase dependency to customers' was found in the case survey which explained a certain issue a company experiences but was not in detail explained in the literature

on CBM implementation issues. Another contribution is that the CBMs proposed by Lüdeke-Freund et al. (2018) were used in order to find them in business practice cases. The business models defined by scientific literature are present in current business practice.

Besides a contribution to literature this thesis might provide contribution to other actors as well. Governments and companies can make use of this work and learn about what companies currently do in the field of CE and what implementation barriers they experience. If these actors acknowledge these barriers, it can help them in their implementation processes of CBMs. Further elaboration and recommendations on this is presented in Chapter 6.

5.3 | Relevance

This section elaborates on why this study is relevant. Merli et al. (2018) stated that more attention should be devoted to CE in academic research. The work of this thesis is relevant for the transition to a CE. It is argued that more knowledge of CBMs, its patterns and its implementation barriers can enhance the CE transition. However, much more is needed for a full CE to happen. Barriers need to overcome, laws and regulations need to change and the mindset of companies needs to change as well. As was mentioned multiple times before, the CE is all about collaboration and companies, governments, suppliers, customers and other parties need to work together to accomplish it. CE cannot be established with one single company or one single country alone. For CE to happen, many changes are needed and currently the principle of CE are not widely adopted. With the arrival of CE companies and their business models need to change. CBMPs can help the BMI process by giving the process the right direction. Therefore this study forms a small part and addition of and to the transition to a CE.

It is argued that the entire field of CE is extremely relevant, especially at the moment, as we are currently using 1.5 of our planet for human activities. It is therefore important that we continue researching the opportunities this concept brings and help companies implement successful and sustainable CE practices. The new technologies and possibilities of CE are found to be very promising.

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Chapter 6 | Conclusion

This last chapter concludes the research and answers the main research question. Section 6.1 recalls the research objective and the (sub) research questions and provides the answers. This section is the main conclusion and will not elaborate on matters that have not been mentioned before. Section 6.2 shows the relevance of this study and this chapter ends with Section 6.3 providing recommendations for different actors.

6.1 | Conclusion to the Main Research Question

Before continuing with the main conclusion, the objective, main research question and sub research questions are recalled from Chapter 1. The full answers to the first two sub research questions can be found in Section 2.8 and the answers to the last two questions are presented in Section 4.12. These answers will be shortly recalled first before the answer to the main research question is given.

The objective of this thesis is: *To find out what circular business model patterns are and what their relation is to circular business models and implementation barriers that circular companies experience. Besides, to investigate what implications circular business model patterns have for companies and how they are placed in the transition from a linear to a more circular economy.*

The main research question is: *Which patterns in circular business models can be identified and what are implications for these patterns for companies and the circular economy?*

Sub research question 1: *What are the main developments on circular business models in scientific literature and the barriers in implementing them for companies?*

Oghazi & Mostaghel (2018) presented three main differences between CBMs and LBMs. CBMs require better alignment with customers, partners and suppliers. Changes are shown in the value chain of a CBM and new cost structures and revenue models are required. CBMs are LBMs with extra aspects focused on the environment, the public and the economy itself. The literature review provided a list of 26 CBMs. The second part of this question focuses on the implementation barriers. 18 barriers have been found with examples being 'Requires technological expertise' and 'Capital tied up'.

Sub research question 2: *What are circular business model patterns and which patterns are identified in literature?*

Combining the definitions of CE and BMPs, the following definition for a CBMP was established: "building blocks in business models for circularity". In literature 11 CBMPs were found, these patterns were adopted from several papers. The patterns are: Access and performance model, adopt a stewardship role, cascading and repurposing, industrial symbiosis, maximize material and energy efficiency, organic feedstock, recycling, refurbishment and remanufacturing, repair and maintenance, reuse and redistribution and substitute with renewable and natural processes. It was found that (C)BMPs are powerful tools for BMI. More than 90% cases of BMI consist of a recombination of existing BMPs. It was also found that BMPs are a valuable approach to describe and understand business logics of new, unknown markets. BMPs do not focus on imitating, but rather address efficiency, spur creativity and help to overcome cognitive barriers in the BMI process, which is of importance in times of transformative change.

Sub research question 3: *Which circular business models, circular business model patterns and implementation barriers can be identified in business practice and are these variables related?*

The research-specific part of the case survey was dedicated to the three variable categories (CBMs, CBMPs and the limitations). Most of the companies in the dataset are involved with either (re)manufacturing (38.2%) or recycling and waste management (29.4%). By far the most assigned CBM was 'Encourage efficiency' and after that 'Waste generation systems'. The limitation for companies seen most is 'Requires technological expertise', followed by 'Return flow challenges', 'Partner restrictions' and 'Customer restrictions' respectively. As was found in the literature, CBMs require more integration between partners and consumers. This is confirmed by that these limitations are present often in those companies. All CBMPs were at least assigned to 5.9% of the case sample. The most assigned CBMPs are 'Adopt a stewardship role', 'Recycling/create value from waste' and 'Refurbishment and remanufacturing' respectively. Besides, some other variables were found. For the list of patterns, the case sample provided two new ones: 'Reverse logistics' and 'Circular solution'. Moreover, a different type of limitation was found that can be described as 'Increase dependency to consumers'. It can be concluded that the variables found in literature are identified in business practice.

Afterwards the relations between the variables were studied, which constitutes the second part of the sub research question. It can be concluded that small and bigger relations exist between CBMPs and CBMs and CBMPs with limitations. There is e.g. CBM 'Encourage efficiency' and CBMP 'Adopt a stewardship role' that were correlated. The problems 'Capital tied up' and 'Operational risk' showed a relation with the pattern 'Access and performance model'. The pattern

'Refurbishment and remanufacturing' was correlated with 'Return flow challenges'. However, some relations were not very strong and sometimes due to the fact that in cluster analysis everything has to be places somewhere, regardless of the missing connection.

Sub research question 4: *How can circular business model patterns become more widely adopted and how can this contribute to a transition to a more circular economy?*
The first part of this sub research question asks how CBMPs can become more widely adopted. An interviewee said that it is important to create awareness and critical mass for CE and its related concepts. There is still a long way to go, but this can be one of the steps to move forward. CE is not something a single actor can reach on its own. It is, compared to the linear economy, a system where much more collaboration is needed. This was both said in the interviews as well as found in literature (Oghazi & Mostaghel, 2018). Better understanding of CBMPs can enhance the transition to a more circular economy. Gassmann et al. (2014) found that many cases of BMI consist of a recombination of existing BMPs. Managers can use these patterns to generate a new business model systematically or adapt an existing one. Innovative business models can be created by the rearrangement of existing CBMPs.

The main research question is: *Which patterns in circular business models can be identified and what are implications for these patterns for companies and the circular economy?*
This question was derived from the knowledge gap, which was formulated as follows: this thesis aims to create a more complete list of patterns and will investigate what value these patterns have for circular companies. This thesis formed a more comprehensive list of CBMPs. 11 were found in scientific literature and 2 during the case survey. This total list of CBPMs is: Access and performance model, adopt a stewardship role, cascading and repurposing, circular solution, industrial symbiosis, maximize material and energy efficiency, organic feedstock, recycling, refurbishment and remanufacturing, repair and maintenance, reuse and redistribution, reverse logistics and substitute with renewable and natural processes.

Managers of companies that have interest or feel the need to implement circular principles can, with help of CBMPs, generate new business models or adapt existing ones. The need of CE is partly due to the worldwide problems the world is experiencing, but also the consumers pushing companies to be more sustainable and take care of the environment. Study shows that BMPs are important tools for BMI as 90% of BMI cases consist of a recombination of existing BMPs. Patterns can be used again and can be a source of information. Furthermore, BMPs help to describe and understand the logics of new, unknown markets. The industries where the companies in this research operate in are not new, but with the arrival of CE a lot in the business processes needs

to change. CBMPs help overcome barriers in the BMI process, which is of high importance in times of transformative change.

6.2 | Recommendations

This section elaborates on what different groups can take from this research. The different groups that are going to be addressed are the academia/scientific literature, policy makers such as governments and companies, both circular and not circular.

6.2.1 | Recommendations for Academia

This group was already discussed in Chapter 5, in the section on the contribution this thesis made. This thesis added knowledge on CBMs and CBMPs both by providing more comprehensive lists of the studies concepts as well as studying these concepts in business practice. Recommendations for this actor group is to continue studying these topics. A general definition for a CBMP has not been established yet, so this might form the first recommendation. Moreover, BMP databases can insert CBMPs to make the database more complete. BMP taxonomies do not necessarily focus on sustainability or circularity, but it is suggested that the existing pattern databases are extended with the findings of this research. Also other companies can be studied regarding their business model. This can happen via a case survey in the same way as was executed in this research, but it also might be interesting to use other methods for this. An example would be single case studies in companies that are currently in a BMI process to be more circular.

6.2.2 | Recommendations for Policy Makers

What is mostly said about policy makers in the field of CE is that these actors could foster the transition to a more circular economy if they change laws and regulations. As an example, the company Black Bear Carbon mentioned that there are still constraints in the current regulation that focuses on the old linear thinking. Black Bear Carbon produces tires from carbon black and faces problems regarding safety regulations. Decision makers that want to positively influence the CE could have a look at the list of implementation barriers that were identified in companies. Especially the problems that were assigned most, which are 'Requires technological expertise' and 'Return flow challenges', might form interesting starting points in helping CE activities. As was elaborated on in the literature review, governments and unions already take action. However, this research shows which problems they should focus on. It is suggested that governments continue working on CE and engage in conversations with companies so that their barriers are taken away or that their CE activities are actively promoted.

6.2.3 | Recommendations for Companies

This main recommendation for companies is that they can make use of the more comprehensive list of CBMPs for their BMI activities. These patterns can be incorporated in their own business models. CBMPs are powerful tools and managers can use these to generate new business models or rearrange their old one. For CE, innovation in business models is needed and patterns can help this innovation in the right direction. The field of CBMPs is interesting for companies as it allows them to have concrete discussions about difficult issues. Furthermore, this thesis looked at many different companies which are also shortly described. This information might be beneficial for managers as well, since most of the companies in the sample are performing very well economically.

6.3 | Future Research

Throughout this research some interesting points were found that could be the start of a future research project. Some of these prospects are elaborated on in this section. The following future research possibilities are suggested:

- No information is available about the success of the companies in the data sample and therefore nothing could be said about the profitability of certain business models or patterns. An interesting direction as continuation of this work is investigating if profitability is related to these concepts. New insights could enhance (new) companies to develop CBMs, as becoming profitable is an important driver for companies.
- As was suggested in the discussion chapter, a well-understood distinction between a CBM and a CBMP has to be established. Clear definitions and more elaboration on current knowledge enhances the knowledge base of these concepts. This point is also brought up because not an overall definition in CBMPs is widely used in scientific literature.
- If the current list of CBMPs is revised and/or extended, a CBMP taxonomy may be established. Here, the taxonomy of Remane et al. (2017) can serve as a template or example on how to do this. The CBMPs can also be added to this pattern database of the authors. A taxonomy could increase the understanding of CBMPs and enhance their practical use.
- Instead of using the case survey methodology, an interview or normal survey approach could be used to study the companies more in-depth. This means that the information comes from the people of the company instead of information that was found online. The interviews and surveys would ask about the business model of the company and elaborates on what the company does in terms of CE. This may decrease the amount of

bias in the data, ensures that less information is left out and makes sure information is always up-to-date. However, these methodologies bring their own limitations.

- Only one case author gave comments on two of the 34 companies. These comments were very helpful and the case author showed that they knew much more about the companies than was reported in their work. This confirms the limitation named by Larsson (1993) that a drawback of (single) case studies is that the reports do mostly not provide all collected data due to space limitations. More case authors could be contacted to gain more information about the companies and personal insights from the authors that researched these companies. This adds to the reliability of the results.
- More cases (thus, the increase of N) could be studied. With this, the hierarchical cluster analysis and chi-square tests can aim to show statistical significance. This is easier for sample sizes that are larger. With a larger sample size, also other statistical methods can be used for the analysis.
- The case survey was performed without a second investigator that codes part of the data a second time. Involvement of a second investigator could increase the reliability of the results and then the interrater reliability could be calculated.
- The factors in the case survey that could be assigned were only 0 and 1. The option (-) was added for variables that were unknown or not applicable. A suggestion to another way of assigning factors is using e.g. high, medium and low. The business models and patterns are then defined as the extent to which they are present in the companies instead of just plainly if they are applicable or not. On a side note, this will increase the difficultness of assigning factors to companies.

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Appendices

A – Longlist of Case Companies

B – Case Survey Protocol

C – Operationalization

D – Case Survey Findings

E – Interview Questions

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Appendix A | Longlist of Case Companies

The search for circular and sustainable companies resulted in a longlist of 188 companies that can be found below.

1 Active Disassembly
2 AELS
3 Agency of Design
4 Agito Medical
5 Agriprotein
6 AHLMA
7 Ahrend
8 Appliance Warehouse of America
9 Aquafil
10 ArcelorMittal Brasil
11 Arla
12 ASDA
13 ASML
14 Atherstone Accident Repair Centre Ltd
15 Auping
16 Autocraft Drivetrain Solutions
17 AVV
18 Balbo Group
19 Barton
20 BB Architects
21 Better World Fashion
22 Bioplus
23 Biototal AB
24 Biteback
25 BlaBlaCar
26 Black Bear Carbon
27 Bosch Siemens Hausgeräte
28 Boska
29 Braiform
30 Brisa
31 British Sugar plc
32 Brocklesby
33 Bugaboo
34 Bundles
35 Canon
36 Caterpillar
37 CBPAK
38 Cirkle
39 Cisco
40 Closing the Loop
41 Coca-Cola Enterprises
42 Coolrec
43 CoreCentrics Solutions
44 Cowell
45 CSC s.r.l.
46 Cyberpac
47 Daas Baksteen
48 Danone-Evian
49 Delta Development Group
50 Desko
51 Desso
52 DLL Group
53 DSM NIAGA
54 Dutch aWEARness
55 Dutch Spirit
56 Dutch Rainmaker
57 Eastex Materials Exchange / Bright Green
58 e-Choupal
59 Ecovative
60 Ecovative Design
61 Ecover
62 Electrolux
63 Enexis
64 eStoks
65 ETAP
66 Evides
67 Excess Materials Exchange
68 Fairphone
69 Fat Lama
70 Finch Buildings
71 FLOOW2
72 Fresh-R
73 Furnishare
74 Gabriel
75 GameStop
76 Gazelle
77 Gerrard Street
78 GH Form
79 Gispen
80 Godsinlösen
81 Greenwheels
82 Grundfos
83 Gyproc
84 H&M
85 Happy Kiddo
86 Heyde Hoeve
87 HP Brazil & Sinctronics
88 HP Instant Ink
89 HVC
90 Inashco
91 Indaver
92 Interface
93 Ioniqa Technologies BV
94 JLG & DLL
95 Kaer
96 Kalundborg Symbiosis
97 Knowaste
98 Kroger
99 Lufa Farms
100 Lyft
101 Maersk Line
102 Marks & Spencer
103 Mazuma Mobile
104 MBD Energy

105 Mic Mac Minuscule
106 Michelin
107 Miele
108 Mitsubishi Electrics
109 Mobility Carsharing
110 Moonen Packaging
111 MUD Jeans
112 Natura Brasil
113 Nespresso
114 New Horizon
115 Norsk Gjenvinning
116 Novelis
117 NS
118 Oberon FMR
119 OCMW Leuven
120 Off2Off
121 Ostara Nutrient Recovery Technologies
122 Park 20/20
123 Patagonia
124 Pay per wash-Electrolux in NL
125 PeerBY
126 Philips Lighting
127 PlantLab
128 PolyPlank AB
129 PPG industries
130 PUMA
131 Qlean Scandinavia AB - Qlean Industry
132 Qmilch
133 RecycleBank
134 Rede Asta
135 REEP Technologies Ltd.
136 Refil
137 ReFood
138 Refuse Vehicle Solutions
139 Renault
140 Repack
141 Replenish
142 Re-Tek
143 Rijks-waterstaat
144 Riversimple
145 Rockwool
146 Rohner
147 Rubies in the Rubble
148 Rype Office
149 SABMiller
150 Samsung
151 Scanenergi
152 Smile Exchange
153 SnappCar
154 Sodastream
155 Solegear bioplastics
156 Splosh
157 StoneCycling
158 Superuse Studios
159 Swapfiets
160 Takao Furuno
161 Tamar Energy
162 Teeuwissen
163 The Plant
164 Toast Ale
165 Tomra
166 Toronto Tool Library and Makerspace
167 Turntoo
168 Uniqlo
169 United Wardrobe
170 Urban Farming
171 Urban Mining Company
172 Van de Sant
173 Van Houtum/WEPA
174 Vanderlande
175 Veolia
176 Vereijken Hooijer
177 Verimpex
178 Vitsoe
179 Vlaamse Confederatie Bouw
180 Waste Trade
181 Waste Trade Company
182 Waternet
183 Winnow
184 Wornagain
185 Xerox
186 Yerdle Recommerce
187 Zen Robotics
188 Zipcar

Appendix B | Case Survey Protocol

The case survey protocol, or coding scheme, is shown in Table 8. There are eight variables, categorized into background variables (Part I) and research-specific variables (Part II).

Table 8. Case survey protocol

PART I: BACKGROUND VARIABLES

		What is asked?	*Multiple answers possible?*	*Output*
1	**Company name**	Name of company	No	Name
2	**Country of origin**	Country where company was founded	No	Selection of countries
3	**Industry sector**	Industry/ies company operates in	Yes	Selection of industries
4	**Company size**	Small or large	No	1. Small (<150 employees) 2. Large
5	**Company phase**	What phase are they in	No	1. Start-up 2. Established

PART II: RESEARCH-SPECIFIC VARIABLES

		What is asked?	*Multiple answers possible?*	*Output*
6	**Circular business models**	Which of the circular business models by Lüdeke-Freud et al. (2018) are presented	Yes	1. Circular supplies 2. Classic long-life model 3. Closed-loop production 4. Co-product generation 5. Cradle-to-cradle 6. Create value from waste 7. Encourage sufficiency 8. Extending product value 9. Extending resource value 10. Industrial symbiosis 11. Online waste exchange platform 12. Product as a service 13. Product life extension 14. Product recycling

				15. Product transformation
				16. Remanufacturing / next-life sales
				17. Rematerialization
				18. Refurbishment
				19. Resource recovery
				20. Service and function-based models
				21. Sharing platforms
				22. Take back management
				23. Upgrading
				24. Waste exchange (external)
				25. Waste exchange (internal)
				26. Waste regeneration systems
				27. Others, namely …
7	**Limitations and challenges**	Limitations and challenges faced by the company, adopted from Linder & Williander (2017); Oghazi & Mostaghel (2018) and Roos (2014)	Yes	1. Capital tied up
				2. Confidentiality for individual firms
				3. Cultural barriers
				4. Customer type restrictions
				5. Economic barriers
				6. Fashion vulnerability
				7. Higher risks for CBM
				8. Increase of dependency to partners
				9. Lack of supporting regulation
				10. Mutual benefits for all partners
				11. No problem owner
				12. Operational risk
				13. Organizational barriers
				14. Partner restrictions
				15. Product category restrictions
				16. Requires technological expertise
				17. Return flow challenges
				18. Risk of cannibalization
				19. Others, namely …
8	**Circular business model patterns**	Circular business model patterns observed in the company, adopted from Lüdeke-Freund et al. (2018); Bocken et al. (2016) and Bocken et al. (2014)	Yes	1. Access and performance model
				2. Adopt a stewardship role
				3. Cascading and repurposing
				4. Industrial symbiosis
				5. Maximize material and energy efficiency
				6. Organic feedstock
				7. Recycling/create value from waste
				8. Refurbishment and remanufacturing
				9. Repair and maintenance
				10. Reuse and redistribution
				11. Substitute with renewable and natural processes
				12. Others, namely …

Appendix C | Operationalization

With the help of this appendix, which presents the operationalization of the case survey, a second rater will be able to carry out the research the same way as the first rater did. This increases the validity of the method and the research. Here, the reader can find how the information about the case companies was assessed.

As shown in Appendix B, the protocol comes in two parts. The first parts exists of generic company information such as name, country of origin, industry, size and phase. These factors can be determined with in a Google or company's website search. The networking social media website LinkedIn was sometimes used to find the number of employees working at a company, to determine the value of the company size factor. In Table 9 all concepts of the second part of the protocol are listed and described. With this, it becomes clear how the protocol for every company was filled in. The factors can have the following three inputs: applies to the company (1); does not apply to the company (0); not known or not specified (-). After reading the company material, the researcher was able to make a decision about which input needed to be filled in.

Table 9. Assigning the concepts to the companies

Concept	When is it assigned
Circular business models *All 26 CBMs and the corresponding definitions are derived from the supporting information (Appendix I and II) of Lüdeke-Freund et al. (2018). The researchers found 37 CBMs in 12 resources and grouped some of them, which brought the number of CBMs to 26. Example companies were copied from the article appendix and this table specifies which business models were grouped.*	
1. Circular supplies Example: Royal DSM	When a company uses its own waste or waste of third parties as inputs for fully renewable, recyclable, or biodegradable products.
2. Classic long-life model Example: Miele's 20-year life span of appliances	When a company designs long-lasting products and offers repair or maintenance services.
3. Closed-loop production Example: Interface	When a company continuously recycles material and takes product back after use.
4. Co-product generation Another CBM that was grouped into this category: Multiple cash flows / multiple revenues	When a company produces co-products based on recycled waste, process residues or byproducts. It generates multiple cash flows and revenues.

Example: British Sugar	
5. Cradle-to-cradle Example: Gabriel	When a company produces products with the cradle-to-cradle certificate. If the company possesses such a certificate can be checked via: www.c2ccertified.org
6. Create value from waste Example: Kalundborg Symbiosis	When a company eliminates the concept of 'waste' by turning waste streams into useful and valuable input.
7. Encourage sufficiency Example: Vitsoe	When a company uses solutions that actively reduce end-user consumption principles such as durability and upgradability.
8. Extending product value Example: Clothing return at H&M	When a company takes back products and uses that or components in as-new quality, exploiting residual value of products.
9. Extending resource value Example: Interface using fishing nets as a raw material for carpets	When a company wins back base materials for new products, exploiting residual value of resources.
10. Industrial symbiosis Example: Kalundborg Symbiosis	When companies are involved in physical exchange of materials, energy, water and byproducts.
11. Online waste exchange platform Example: Smile Exchange	When a company brings together users and producers of waste.
12. Product as a service Other CBMs that were grouped into this category: Product lease; Product renting or sharing Example: car sharing	When the ownership is retained by the company and offers product access.
13. Product life extension Example: Project Ara from Google	When a company extends the product life by designing long-lasting products, repairing, upgrading, remanufacturing or remarketing of products.
14. Product recycling Other CBMs that were grouped into this category: Product recycling / Recycling 2.0; Recycling and waste management Example: Arla	When a company recycles, which is the process of winning back base materials from used products, but loses much of the added (or embodied) value (energy, labor and use of capital).

15. Product transformation Example: Clothing return at H&M	When a company wins back components from used products.
16. Remanufacturing / next-life sales Example: Bosch	When a company remanufactures its products, which is the process of restoring the product or part functionality to "as-new" quality.
17. Rematerialization Example: Knowaste	When a company develops innovative ways to source materials from recovered waste, creating entirely new products.
18. Refurbishment Other CBMs that were grouped into this category: Repair; Reuse / refurbish / maintain / redistribute / next-life sales; Reuse Example: Godsinlösen	When a company uses direct secondary re-usage or resale extending the product life so that the company can put the same products into the market to gain a second or third income.
19. Resource recovery Example: Kroger	When a company recovers useful resources and/or energy out of disposed products or by-products.
20. Service and function-based models Other CBMs that were grouped into this category: functional sales and management service models; deliver functionality, rather than ownership; functional result; pay per service unit; access and performance model Example: Xerox	When a company switching from product to service and asks payments per use.
21. Sharing platforms Example: Lyft	When a company establishes a platform where collaboration amongst product users is possible.
22. Take back management Example: Desso	When a company takes back used products from distributors and end-users.
23. Upgrading Example: a modular phone	When a company replaces outdated modules or components with superior ones.
24. Waste exchange (external) Example: Eco-industrial parks	When a company uses external waste as an input.
25. Waste exchange (internal) Example: AB sugar	When a company uses their own waste as an input, this model is different than co-product generation (#4)

	because the waste is not intended for the external market (Albino & Fraccascia, 2015).
26. Waste regeneration systems Example: Brisa	When a company uses a system that is based on the re-use or recycling of waste as new products. This business model is focused on valuing waste, or using it as an input for a new product to be sold on the market (Beltramello et al., 2013).
27. Others, namely …	When assessing the company, other CBMs can be brought forward by the researcher.
Challenges and limitations *The list is a summation of challenges and limitations proposed by different researchers. To explain the different concepts, multiple works were used (Linder & Williander, 2017; Oghazi & Mostaghel, 2018; Roos, 2014).*	
1. Capital tied up From Linder & Williander (2017)	When a company has ownership of the product (in e.g. a product as a service model), the financial risk transfers from the customer to the producer. Cash flows are different and major upfront investments are needed.
2. Confidentiality for individual firms From Oghazi & Mostaghel (2018)	When a company experiences troubles with information exchange.
3. Cultural barriers From Oghazi & Mostaghel (2018)	When a company experiences the fear of the unknown from organizations and individuals.
4. Customer type restrictions From Linder & Williander (2017)	When a company produces certain products or offers certain services that only appeal to certain types of customers. Linder & Williander (2017) name six types of customers that are suitable for remanufacturing: (1) customers who need to retain a specific product for their processes; (2) customers that want to avoid reapproving a product; (3) customers that make low utilization of new equipment and are price sensitive; (4) customers that want to continue using a discontinued product; (5) customers that want to extend the life of a used product and (6) customers that are environmentally interested. This box needs to be ticked if the products or services of a company might give reactions like the ones mentioned above.

5. Economic barriers From Oghazi & Mostaghel (2018)	When a company needs different skills and resources for CE that are more expensive.
6. Fashion vulnerability From Linder & Williander (2017)	When a company produces circular products in an industry where aesthetic attributes play an important role for the attractiveness of that product.
7. Higher risks for CBM From Oghazi & Mostaghel (2018)	When a company needs to sell its circular product more than one time before validation.
8. Increase of dependency to partners From Oghazi & Mostaghel (2018)	When a company experiences more dependency (and thus risk) to others due to collaboration.
9. Lack of supporting regulation From Linder & Williander (2017)	When a company experiences challenges with policy, laws and/or regulations. An example, taxes tend to be levied on labor rather than raw materials.
10. Mutual benefits for all partners From Oghazi & Mostaghel (2018)	When a company has e.g. misaligned profit sharing along its supply chain.
11. No problem owner From Roos (2014)	When a company focuses on their business being viable and in a lesser, or even none extent on being the problem owner of e.g. worldwide resource depletion.
12. Operational risk From Linder & Williander (2017)	With a product as a service model, the liability and operation risk of the customer transfers to the firm.
13. Organizational barriers From Oghazi & Mostaghel (2018)	When a company experiences troubles with changing the organization and experiences resistance from employees.
14. Partner restrictions From Linder & Williander (2017)	When a company works tightly together with other parties such as suppliers, this can cause hurdles.
15. Product category restrictions From Linder & Williander (2017)	When a company deals with products that are not (fully) suitable for reuse or remanufacturing.
16. Requires technological expertise From Linder & Williander (2017)	When a company wants to remanufacture a product, considerable knowledge and expertise is required.
17. Return flow challenges From Linder & Williander (2017)	When a company has troubles with predictability and reliability of the return flow (in e.g. take back management or maintenance). Difficulties are formed in capacity planning.

18. Risk of cannibalization From Linder & Williander (2017)	When a company produces new longer-lasting products that result in a decrease of sales of their older, shorter-lasting products.
19. Others, namely …	When assessing the company, other challenges and limitations can be brought forward by the researcher.
Circular business model patterns *The list is a summation of patterns proposed by different researchers. To explain the different concepts, multiple works were used (Lüdeke-Freund et al., 2018; Bocken et al., 2016; Bocken et al., 2014). In this list six patterns belong, according to the papers, to certain CBMs. These are mentioned.*	
1. Access and performance model Also called: Deliver functionality rather than ownership From Bocken et al. (2016) and Bocken et al. (2014)	Companies that provide the capability or services to satisfy user needs without needing to own physical products.
2. Adopt a stewardship role From Bocken et al. (2014)	Companies that take a stewardship role, e.g. biodiversity protection, consumer care – promote consumer health and well-being, ethical trade (fair trade), choice editing by retailers, radical transparency about environmental/societal impacts, resource stewardship.
3. Cascading and repurposing Belongs to CBM 'co-product generation from waste'. From Lüdeke-Freund et al. (2018)	Companies that are inspired with the "waste is food" principle, it describes the iterative use of the energy and material contents of physical objects (e.g., a tree), leading to productive processes that are fed purely by external energy input (e.g., from the sun).
4. Industrial symbiosis From Bocken et al. (2016)	Companies that are involved in industrial symbiosis, a process-orientated solution, concerned with using residual outputs from one process as feedstock for another process, which benefits from geographical proximity of businesses.
5. Maximize material and energy efficiency From Bocken et al. (2014)	Companies involved with e.g. low carbon solutions, lean manufacturing, additive manufacturing, de-materialization (of products/packaging) and increased functionality (to reduce total number of products required). This also includes solutions that actively seek to reduce end-user consumption.

6. Organic feedstock Belongs to CBMs 'co-product generation from waste', 'circular supplies', 'resource recovery' and 'industrial symbiosis'. From Lüdeke-Freund et al. (2018)	Companies that process organic residuals via biomass conversion, compositing, or anaerobic digestion. The last is a "process in which microorganisms break down organic materials, such as food scraps, manure, and sewage sludge, in the absence of oxygen" (EMF, 2012, p. 25).
7. Recycling/create value from waste Belongs to CBMs 'closed-loop production', 'rematerialization' and 'product recycling'. From Bocken et al. (2014) and Lüdeke-Freund et al. (2018)	Companies that are e.g. involved in down- and upcycling. Downcycling means the recycling process converts the product in something with a lower value, upcycling is the other way around.
8. Refurbishment and remanufacturing Belongs to CBMs 'remanufacturing / next-life sales', 'upgrading', 'product life extension' and 'extending product value'. From Lüdeke-Freund et al. (2018)	Companies that use combinations of the repair and maintenance and the reuse and redistribution capabilities and business model design options (e.g., in terms of value delivery processes).
9. Repair and maintenance Belongs to CBMs 'refurbishment', 'product life extension' and 'classic long-life model'. From Lüdeke-Freund et al. (2018)	Companies involved with principles such as services for customers, using forward and reserve logistics, up-to-date product expertise, fast learning and problem-solving capabilities.
10. Reuse and redistribution Belongs to CBMs 'refurbishment' and 'product life extension'. From Lüdeke-Freund et al. (2018)	When companies offer access to used products and evaluate the market value of their products, which might include slight enhancements or modifications, and creating a market place.
11. Substitute with renewable and natural processes From Bocken et al. (2014)	Companies that move from non-renewable to renewable energy sources, solar and wind-power based energy innovations, zero emissions initiative, blue economy, biomimicry, the natural step, slow manufacturing and green chemistry.

12. Others, namely …	When assessing the company, other CBMPs can be brought forward by the researcher.

It is information resource specific if the questions above can be answered for the company. It will be highly probable that most of the limitations and challenges cannot be found directly in the information resources. However, with expert knowledge of the researcher it can be determined if the company would experience such a hurdle to an extent or not.

Appendix D | Case Survey Findings

The findings of the case survey for the selected companies are divided into different parts. The background variables (part I) of the companies can be found in section D.1. An overview of used information resources per company and a small description of the company is presented in section D.2. Section D.3 shows tables of part II of the case survey findings, which are the research-specific variables.

D.1 | Background Variables

Table 10. Background variables of the case survey protocol

	Company name	Country of origin	Industry sector	Company size	Company phase
1	Aquafil	Italy	Nylon yarn production	Large	Established
2	Auping	The Netherlands	Bed and mattress manufacturing	Large	Established
3	Autocraft Drivetrain Solutions	United Kingdom	Engine manufacturing	Large	Established
4	Black Bear Carbon	The Netherlands	Tires recycling and manufacturing	Small	Start-up
5	Braiform	United States	Garment hanger reuse	Large	Established
6	Brocklesby	United Kingdom	Waste management and recycling	Small	Established
7	Caterpillar	United States	Heavy machinery manufacturing	Large	Established
8	Cisco	United States	Networking equipment	Large	Established
9	Coca-Cola Enterprises	United States	Beverages	Large	Established
10	Desso	The Netherlands	Carpet manufacturing	Large	Established
11	DSM Niaga	The Netherlands	Carpet manufacturing	Small	Start-up
12	Ecovative	United States	Biotechnology	Small	Start-up
13	Fairphone	The Netherlands	Modular phone manufacturing	Small	Start-up
14	Fat Lama	United Kingdom	Product sharing platform	Small	Start-up

15	FLOOW2	Luxembourg	B2B sharing platform	Small	Start-up
16	Furnishare	United States	Furniture sharing	Small	Start-up
17	GameStop	United States	Electronics refurbishment and recycling	Large	Established
18	GreenWheels	The Netherlands	Car sharing	Small	Established
19	Interface	United States	Carpet manufacturing	Large	Established
20	Kalundborg Symbiosis	Denmark	Eco-industrial park	Large	Established
21	Maersk Line	Denmark	Container shipping	Large	Established
22	Mazuma Mobile	United Kingdom	Mobile phone reuse and recycling	Small	Established
23	Mobility Carsharing	Switzerland	Car sharing	Large	Established
24	MUD Jeans	The Netherlands	Jeans leasing	Small	Start-up
25	Park 20/20	The Netherlands	Industrial park	Small	Start-up
26	PeerBY	The Netherlands	Product sharing platform	Small	Start-up
27	Philips Lighting	The Netherlands	Light as a service	Large	Established
28	REEP Technologies Ltd.	Israel	Paper remanufacturing	Small	Start-up
29	Refuse Vehicle Solutions	United Kingdom	Vehicle remanufacturing	Small	Established
30	Replenish	United States	Reusable packaging bottles	Small	Start-up
31	Re-Tek	United Kingdom	IT disposal and asset retirement	Small	Established
32	Rype Office	United Kingdom	Furniture	Small	Start-up
33	Splosh	United Kingdom	Cleaning packaging	Small	Start-up
34	The Plant	United States	Industrial symbiosis	Small	Start-up

D.2 | Information Resources

In the following section the studied case companies are shortly introduced and an overview of used information resources are listed.

1 | Aquafil

The company is involved in yarn production. It has designed a system where waste yarn is manufactured into new nylon yarn without decrease in quality. It works with used fishing nets and works together with companies such as Desso, the carpet manufacturer that is also studied in this research. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018);
- The case study 'Production of nylon yarn from waste materials' (EMF, 2018a).

Notes brought up when filling in the protocol:

- Aquafil does not have a C2C certification, however, the nylons it produces are used in carpets from Egetaepper, a Danish carpet manufacturer. Egetaepper's product is Cradle to Cradle™ Certified.

2 | Auping

The company is a bed and mattress manufacturer and focuses on circularity. It has a take back system for old mattresses and a partnership with a mattress recycler. To study this company the following resources were used:

- The company's website;
- The Dutch book 'Route Circulair' (Ewen et al., 2017);
- The case study in the chapter 'Eco Efficiency and Circular Production: Cases from the Netherlands' Eastern Region' (Den Butter & Webers, 2018);
- The book chapter 'Towards Understanding Collaboration Within Circular Business Models' (Brown et al., 2018).

Notes brought up when filling in the protocol:

- Auping is involved in take back management of its mattresses. It does not recycle the mattresses itself, but sustains a partnership with a mattress recycler.
- The product as a service/access and performance model with Landal GreenParks is a pilot it is involved in.

3 | Autocraft Drivetrain Solutions

The company offers a range of products and solutions. It produces new engines, but also remanufactures engines and recycles different types of metals. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Remanufacturing in the automotive industry' (EMF, 2018b).

Notes brought up when filling in the protocol:

- The partner restrictions limitation was ticked because the company works together with its OEMs, to design with remanufacturing in mind.

4 | Black Bear Carbon

The company generates black carbon from end-of-life tires, which is a substance that can be used for production of new products that have a black color. The remaining parts of the tires are transformed to oil and gas, resulting in the fact that the company takes more CO_2 out of the air than that it consumes. To study this company, the following information resources were used:

- The company's website;
- The case study on CBM implementation of the company, a thesis by Cha (2017);
- The case study 'Black Bear Carbon: The World's First Green Carbon Black' featured on Circle Economy (Circle Economy, 2018b).

Notes brought up when filling in the protocol:

- There are still constraints in the current regulation that focuses too much on the old linear thinking. This was explicitly mentioned by the company.

Notes brought up by the case author:

- Comment: "One of the biggest challenges of BBC was proving quality to customers since [the] tire is directly related to driver's safety". Because of this, 'customer type restrictions' was ticked.
- Comment: "Co-product generation can be added, as the remaining parts of the tire are transformed to oil and gas". Because of this, 'co-product generation' was ticked.

5 | Braiform

The company operates in garment hanger reuse. Its products are returned to reuse centers, there they are sorted, repackaged and redistributed. The established company was first a garment

hanger producer, but decided to sell all production facilities and now focuses on the re-use supply chain. Hangers that cannot be reused, are recycled. This is possible because the hangers are made of only one material. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Achieving re-use at scale in the fast moving consumer goods sector' (EMF, 2018c).

6 | Brocklesby

The company is a waste management and recycler of different kind of materials. It works with retailers and food manufacturers and use its waste cooking oil and food for the biofuels industry. It also offers recycling options for by-products such as food and oil sludges, tank bottoms and waste water. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Unlocking value from used cooking oils' (EMF, 2018d).

7 | Caterpillar

The company is involved in the remanufacturing of its products. The customer pays a deposit for the product and this economic incentive ensures that Caterpillar can do the remanufacturing of the product. It also tries to make the customer aware of sustainability and circularity. To study this company, the following information resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018);
- The case study 'Design and business model considerations for heavy machinery remanufacturing' (EMF, 2018e).

Notes brought up when filling in the protocol:

- Customer type restrictions is a limitation it names explicitly. Quote of interview with Matt Bulley, EAME Product Manager: "People think [the remanufactured product] means washed, painted, repaired, second hand and so on. It is a challenge to convince and educate the consumer that they are getting the same performance at 50-60% of the cost of new" (Urbinati et al., 2017, p. 495)

8 | Cisco

The company refurbishes its own products, tries to extend the product life and wants to increase the percentage of take back management. Currently, it is looking into creating a leasing or "as a service" model for its hardware, which is now only 'normally' sold. To study this company, the following information resources were used:

- The company's website;
- The Corporate Social Responsibility (CSR) report of 2017 (Cisco, 2018);
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018).

Notes brought up when filling in the protocol:

- As the CSR report is very detailed and contains a lot of information, it is sometimes hard to determine what it does exactly and what not. Some things mentioned can be put into 'processes we want to do' or 'things we want to achieve' instead of actual CE practices.
- The access and performance model CBMs and CBMPs were not ticked, however, the company is currently researching it.

9 | Coca-Cola Enterprises

The company is the world's largest beverage company and contains more than 500 brands. Here, not the whole company will be studied, but only the part that focuses on CE. It is committed to supporting a CE and is currently involved in a project called 'A world without waste'. By 2030, it wants its packaging to be 100% recyclable. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The company's sustainability report of 2017 (Coca-Cola Enterprises, 2018).

10 | Desso

The company is Cradle to Cradle™ Certified in its carpet and flooring manufacturing and remanufacturing. It has ambitions to grow further in CE and sustainability, an example of that is that it wants to fully use renewable energy by 2020. To study this company, the following information resources were used:

- The company's website;
- The Corporate Social Responsibility (CSR) report 2015 (Desso Group, 2016);
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The book chapter 'Towards Understanding Collaboration Within Circular Business Models' (Brown et al., 2018);

- The case study 'Cradle to Cradle design of carpets' (EMF, 2018f).

11 | DSM Niaga

The company is a joint venture of DSM and Niaga. It uses a technology that fully recycles the carpet that the company offers. In the production no waster has to be used, in contrast to all other carpet manufacturing techniques. To study this company, the following information resources were used:

- The company's website;
- The case study on CBM implementation of the company, a thesis by Cha (2017);
- The case study '100% recoverable and recyclable carpet material' (EMF, 2017).

Notes brought up by the author:

- Comment: "DSM Niaga produces mono material carpet and compared to other carpet manufacturers who use multiple materials, that is a big limitation when it comes to design". Because of this, 'fashion vulnerability' was ticked.

12 | Ecovative

The company produces packaging products that are fully compostable (biofarbrication). This is made from mycelium, which are the roots of mushrooms. The material is of low economic value, as it cannot be used for food. After the use, the products can be composted at home. To study this company the following resources were used:

- The company's website;
- The article on skills and capabilities for a sustainable and circular economy (De los Rios & Charnley, 2017);
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018);
- The case study 'Growing alternatives to petroleum-based packaging' (EMF, 2018g).

Notes brought up when filling in the protocol:

- The material used (mycelium) is not really waste, but has low economic value. Because of the low value, it is considered as waste here.
- It can only be a closed-loop production if the end-user composts the material. If the customer throws it away as normal waste, the product is not circular.

13 | Fairphone

The company produces a modular smartphone and raises awareness for conflict materials in consumer electronics. Besides the modularity, the company incorporates ease of repair to maximize product lifetimes. To study this company the following resources were used:

- The company's website;
- The Dutch book 'Route Circulair' (Ewen et al., 2017);
- An article on a circular business model mapping tool including a case study (Nußholz, 2018);
- The book chapter 'Towards Understanding Collaboration Within Circular Business Models' (Brown et al., 2018).

14 | Fat Lama

The company is a peer-to-peer sharing platform for technical equipment. It contributes to the 'access over ownership' principle that is seen more often in CE. The website is free to list and browse, but the company takes a percentage of the borrowing purchase. Some categories of products are cameras, cars, drones, DJ equipment and gaming. To study this company the following resources were used:

- The company's website;
- The Dutch book 'Route Circulair' (Ewen et al., 2017);
- The case study 'Borrow stuff you need. Lend stuff you don't.' (EMF, 2018h).

15 | FLOOW2

The company operates in the software and online services industry. It is the first B2B sharing marketplace and tries to reduce overcapacity of goods by matching supply and demand. A company can rent or buy goods that it needs directly from another company that is in the platform. With this, companies can interact in a closed way and create a more circular company. To study this company, the following information resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Business-to-business asset sharing' (EMF, 2018i).

16 | Furnishare

The company operates as a B2C platform, allowing people to donate their unwanted or underutilized furniture and monetize from selling them to other people instead of disposing their stuff. Besides the online market place, the business provides cleaning, repair, storage and

inventory analysis to create a hassle-free and tailored service to customers. To study this company, the following information resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'The final stop for quality furniture' (EMF, 2018j).

17 | GameStop

This is a large company operating in the electronic and electronical equipment industry. It was originally a software and video games retailer, but now creates value by adopting a refurbishing and recycling model for games but also for other kinds of electronics. In its trade-in program, it takes in CDs, electronic devices and accessories to either refurbish or recycle them. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Retailer shifts to remanufacturing' (EMF, 2018k).

Notes brought up when filling in the protocol:

- Something that is seen not only in this company, but in more companies in this research, is that reverse logistics plays a very important role due to take back management. A pattern is that reverse logistics plays an important role in the company.

18 | Greenwheels

The company is a car sharing provider with 1700 cars in the Netherlands. There are different subscriptions for customers available and it has connections with the NS, the principal railway operator in the Netherlands. To study this company the following information resources were used:

- The company's website;
- A news article where the business plan of the company is decomposed (Emerce, 2004);
- The case study as part of research to study business models for sustainability, a thesis by Van Ginkel (2016).

19 | Interface

The company is an established carpet manufacturer and produces modular carpet. In the year 2020 it wants to have no impact on the environment anymore, which is recalled to as Mission Zero. This mission contains seven goals: eliminate waste, benign emissions, renewable energy, closing the loop, resource efficient transportation, sensitizing stakeholders and redesign

commerce. It focuses on closed-loop production and has a lease model for its carpet. To study this company the following information resources were used:

- The company's website;
- An article that conceptualized a sustainable business model for the company (Stubbs & Cocklin, 2008);
- White paper published by Interface on the new industrial model (Interface, 2014);
- The case study in the chapter 'Eco Efficiency and Circular Production: Cases from the Netherlands' Eastern Region' (Den Butter & Webers, 2018);
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018).

20 | Kalundborg Symbiosis

This organization is an eco-industrial park in Kalundborg (Denmark). Companies collaborate by using each other's by-products and they share resources, examples being steam, ash, gas, heat or sludge. It consists of nine partners and is run by a board. To study this collaboration of companies the following information resources were used:

- The organization's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Effective industrial symbiosis' (EMF, 2018l).

Notes brought up when filling in the protocol:

- As this is not one company, but rather a collection of companies that collaborate, some of the factors cannot be filled in. E.g., some of the companies may be involved in closed-loop production, but others may not.

21 | Maersk Line

The company is operating in the shipping industry and in terms of CE, it established a cradle-to-cradle passport which tells the company where improvements in ship construction can be made. The passport contains all materials that were used in the construction. The result of this passport is that materials can be sorted and processed more effectively, maintaining their inherent properties and commanding a better price when it is re-sold. To study this company the following resources were used:

- The company's website;
- Conference proceedings on enabling CE through product stewardship (Jensen & Remmen, 2016);
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018);

- The case study 'Using Product Passports to improve the recovery and reuse of shipping steel' (EMF, 2018m).

22 | Mazuma Mobile

The company provides the service that customers can hand in their old mobile phones, that it will reuse or recycle. The customers get a payment in return for this. In collaboration with a partner, collected handsets are refurbished. The customers will get a free sales pack after they register, so they can post the package with their phone. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Collection, refurbishment and resale of mobile phone handsets' (EMF, 2018n).

23 | Mobility Carsharing

The company has almost 3000 vehicles in Switzerland and Liechtenstein, customers pay for the cars according to how many hours and kilometers they drove. These costs include fuel, insurance and maintenance. To study this company the following information resources were used:

- The company's website;
- The case study in the article on innovative business models with environmental benefits (COWI, 2008);
- Annual report of the company (Mobility Carsharing, 2017);
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018).

Notes brought up when filling in the protocol:

- The protocol was filled in exactly the same way as was done for Greenwheels, the company's Dutch equivalent. The companies are both involved in car sharing, but Mobility Carsharing is larger.

24 | MUD Jeans

The company leases jeans as a service and tries to reduce waste by encouraging the reuse of fibers. The company is against the hype of 'fast fashion'. The jeans they produce are made of 40% recycled material. After a year of leasing the jeans, the customer has three options: first option is to swap their jeans for a new one, second option is to keep the jeans as long as they want or the third option is to stop with the contract. To study this company the following information resources were used:

- The company's website;

- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The article on lessons learned from 8 experimenting CBM cases by Bocken et al. (2018);
- The book chapter 'Towards Understanding Collaboration Within Circular Business Models' (Brown et al., 2018);
- The case study 'Pioneering a lease model for organic cotton jeans' (EMF, 2018o).

25 | Park 20/20

The organization is the world's first full Cradle to Cradle™ Certified optimized work environment and forms a community. It is an office area with closed cycles of water, waste and energy located near the main airport of the Netherlands, Schiphol, in Hoofddorp. Buildings are built with circular supplies. Different companies are established in the park. To study this company the following resources were used:

- The company's website;
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018);
- An article studying CE in the building sector (Leising et al., 2018).

26 | PeerBY

The company is a Dutch online product sharing platform. On the website, customers can place items that others can pick up and use, and customers can look for utilities they need. Items available on the website vary from drilling machines and bar tables to tents and moving boxes. To study this company, the following information resources were used:

- The company's website;
- An article on successful sustainable business models with a case study (Piscicelli et al., 2016);
- An exploratory study of consumer issues in online P2P platform markets (Hausemer et al., 2017);
- The article on lessons learned from 8 experimenting CBM cases by Bocken et al. (2018).

27 | Philips Lighting

The company sells light as a service, this means that the customer pays for the light and not for the fixture. The company is responsible for the maintenance and potential repairs. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);

- White papers published by Philips on circular design (Philips Lighting, 2017a), new business models for a CE (Philips Lighting, 2017b) and reverse logistics (Philips Lighting, 2017c);
- The annual report of 2017 of the company (Koninklijke Philips N.V., 2018);
- The article on lessons learned from 8 experimenting CBM cases by Bocken et al. (2018);
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018);
- The book chapter 'Towards Understanding Collaboration Within Circular Business Models' (Brown et al., 2018);
- The case study 'Selling light as a service' of Philips and Turntoo by the Ellen McArthur Foundation (EMF, 2018p).

28 | REEP Technologies Ltd.

The company developed the REEP process. It exists of an erasable paper and a device containing a laser that can erase the page, it erases the toner. The papers can be re-used ten to twenty times. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'A new circular approach towards paper use in the digital era' (EMF, 2018r).

Notes brought up when filling in the protocol:

- Not a lot of information was found, therefore it was hard to fill in the protocol.

29 | Refuse Vehicle Solutions

The company does major modifications, repairs, maintenance services and more for refuse vehicles. It has divided the life cycle of such a vehicle into four stages: new, quality used, remanufactured, parts. For every stage the company can help: maintenance for new vehicles, remanufacturing for vehicles so that old parts get replaced and at the end of the life cycle, it will dismantle it and recondition it for parts. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Remanufacturing of refuse vehicles' (EMF, 2018s).

30 | Replenish

The company operates in the fast-moving consumer goods (FMCG) and packaging industry and tries to eliminate the waste of plastic bottles. It produces reusable packaging bottles that are

designed to mix liquid concentrate refill pods with water. As an example, the actual chemicals in a cleaner is less than 10% of the bottle, the rest is water. The consumer can add the water themselves, saving lots of packaging material and costs. The company therefore contributes to saving money along the whole supply chain. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Customisable packaging platform for liquid concentrates' (EMF, 2018t).

Notes brought up when filling in the protocol:

- It is hard to assign CBMs and CBMPs to this product, as it is a completely new found product that tackles a very big problem that occurs in the industry. Most business models from the literature focus on the initial product and try to extend or remanufacture it. It is also not 'rematerialization', where you still focus on the initial product. This design could be put as 'circular innovation'.

31 | Re-Tek

The company is involved in IT disposal and asset retirement. It offers services such as IT re-sale, refurbishment, decommissioning and redeployment. Concerning CE, it has signed up to the Electrical and Electronic Sustainability Action Plan 2025 in 2017. Its reverse logistics has been recognized as an example of best practices by the Zero Waste Scotland organization. To study this company the following resources were used:

- The company's website;
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Establishing a reverse supply chain for electronics' (EMF, 2018q).

32 | Rype Office

The company is an office furniture company that reuses, repairs and remanufactures furniture. Basically, there are three options available to customers. The first is purchasing new furniture and returning it in a buy-back scheme, which resembles an access instead of ownership model. The second option is to purchase remade furniture from existing feedstock. The last option is to have existing furniture refreshed by the company. To study this company the following resources were used:

- The company's website;
- The article on skills and capabilities for a sustainable and circular economy (De los Rios & Charnley, 2017);

- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'Circular economy options in office furnishing' (EMF, 2018u).

33 | Splosh

The company specializes in cleaning packaging. Its main offering is a starter kit with filled cleaning bottles, which is no different than normal cleaning items. When the product is finished, refills can be ordered. The customer gets the concentrate and fills it up with warm water. The cleaning bottles are not recycled; they are reused. This leads to 97.5% less waste, according to the company. To study this company the following resources were used:

- The company's website;
- The article on skills and capabilities for a sustainable and circular economy (De los Rios & Charnley, 2017);
- The article on a new CBM taxonomy studying case studies by Urbinati et al. (2017);
- The case study 'How re-thinking the business model for cleaning products can influence design' (EMF, 2018v).

34 | The Plant

This organization is a vertical farm and food incubator in Chicago and operates in a former meat-packaging plant. It plans to house sixteen food businesses such as a bakery, tea- and beer brewery, shared kitchen and mushroom farm. To study this company the following resources were used:

- The company's website;
- An article on urban food sustainability (Chance et al., 2017);
- The article on BMI for amongst others CE in 143 case studies by Diaz Lopez et al. (2018);
- The case study 'Synergistic food production space' (EMF, 2018w).

Notes brought up when filling in the protocol:

- As this is not one company, but rather multiple companies working together, sometimes factors cannot be filled in.

D.3 | Research-Specific Variables

This section presents the results of the second part of the case study protocol. These are the circular business model question (6th variable in the protocol), the limitations and challenges question (7th variable) and the circular business model patterns question (8th variable). An one (1) is assigned when a company complies to that point and a zero (0) if that is not the case. In the case where a factor cannot be found or does not apply, unknown (-) is put. A X was put if a not-listed model or pattern was found. These cases are incorporated in the results chapter (Chapter

4) and also in Section D.2 placed at the corresponding company. There are two tables per variable, the first table presents the first half of the companies (1-17) and the second table companies 18-34. Table 11 and 12 show the companies assigned with the CBMs, Table 13 and 14 show the limitations and challenges and Table 15 and 16 show the CBMPs in the next few pages.

Table 11. Case survey CBMs companies 1-17

		1. Aquafil	2. Auping	3. Autocraft Drivetrain Solutions	4. Black Bear Carbon	5. Braiform	6. Brocklesby	7. Caterpillar	8. Cisco	9. Coca-Cola Enterprises	10. Desso	11. DSM Niaga	12. Ecovative	13. Fairphone	14. Fat Lama	15. FLOOW2	16. Furnishare	17. GameStop
6. Circular business models																		
1	Circular supplies	1	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0
2	Classic long-life model	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0
3	Closed-loop production	0	0	0	1	1	0	1	0	0	1	1	1	0	0	0	0	0
4	Co-product generation	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Cradle-to-cradle	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0
6	Create value from waste	1	1	1	1	1	1	0	0	0	0	1	1	1	0	0	0	0
7	Encourage sufficiency	0	1	1	0	1	1	1	1	0	1	1	0	1	1	1	1	1
8	Extending product value	0	0	1	0	1	0	1	1	0	1	0	0	1	0	0	1	1
9	Extending resource value	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0
10	Industrial symbiosis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Online waste exchange platform	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Product as a service	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
13	Product life extension	0	0	1	0	1	0	1	1	0	1	0	0	1	0	0	1	1
14	Product recycling	1	1	1	1	1	0	0	0	0	1	1	0	0	0	0	0	1
15	Product transformation	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0
16	Refurbishment	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	1
17	Remanufacturing/next-life sales	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	0	1
18	Rematerialization	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0
19	Resource recovery	1	1	1	1	1	1	0	0	1	1	1	0	0	0	0	0	0
20	Service and function-based models	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	Sharing platforms	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0
22	Take back management	1	1	0	0	1	0	1	1	1	1	1	0	1	0	0	1	1
23	Upgrading	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
24	Waste exchange (external)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
25	Waste exchange (internal)	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
26	Waste regeneration systems	1	1	1	1	1	1	0	0	1	1	1	1	0	0	0	0	1
27	Others, namely ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 12. Case survey CBMs companies 18-34

		18. Greenwheels	19. Interface	20. Kalundborg Symbiosis	21. Maersk Line	22. Mazuma Mobile	23. Mobility Carsharing	24. MUD Jeans	25. Park 20/20	26. PeerBY	27. Philips Lighting	28. REEP Technologies Ltd.	29. Refuse Vehicle Solutions	30. Replenish	31. Re-Tek	32. Rype Office	33. Splosh	34. The Plant
6. Circular business models																		
1	Circular supplies	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	-
2	Classic long-life model	0	1	-	0	0	0	0	-	0	1	0	0	0	0	1	0	-
3	Closed-loop production	0	1	-	0	0	0	0	-	0	0	1	0	0	0	0	0	0
4	Co-product generation	0	0	1	0	0	0	0	-	0	0	0	0	0	0	0	0	1
5	Cradle-to-cradle	0	1	0	0	0	0	0	-	0	0	0	0	1	0	0	0	0
6	Create value from waste	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1
7	Encourage sufficiency	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
8	Extending product value	0	1	-	1	1	0	1	1	0	1	1	1	0	1	1	1	-
9	Extending resource value	0	1	-	1	1	0	1	1	0	1	1	0	0	0	0	0	-
10	Industrial symbiosis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
11	Online waste exchange platform	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Product as a service	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
13	Product life extension	0	1	-	1	1	0	0	0	0	1	1	1	0	1	1	1	-
14	Product recycling	0	1	-	0	1	0	1	-	0	0	0	1	0	0	0	0	-
15	Product transformation	0	1	-	0	0	0	0	-	0	1	0	0	0	1	1	0	0
16	Refurbishment	0	1	-	1	1	0	1	-	0	1	0	1	0	1	1	0	0
17	Remanufacturing/next-life sales	0	1	-	0	1	0	0	-	0	1	0	1	0	1	1	0	0
18	Rematerialization	0	0	-	0	0	0	0	-	0	0	0	0	0	0	0	0	0
19	Resource recovery	0	1	-	1	1	0	1	1	0	1	1	0	0	0	0	0	0
20	Service and function-based models	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
21	Sharing platforms	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
22	Take back management	0	1	-	0	0	0	1	0	0	1	0	0	0	1	1	0	0
23	Upgrading	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	Waste exchange (external)	0	0	1	0	0	0	0	-	0	0	0	0	0	0	0	0	1
25	Waste exchange (internal)	0	0	-	0	0	0	0	-	0	0	0	0	0	0	0	0	1
26	Waste regeneration systems	0	0	1	1	1	0	1	-	0	0	1	1	0	1	1	0	1
27	Others, namely …	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 13. Case survey limitations companies 1-17

		1. Aquafil	2. Auping	3. Autocraft Drivetrain Solutions	4. Black Bear Carbon	5. Braiform	6. Brocklesby	7. Caterpillar	8. Cisco	9. Coca-Cola Enterprises	10. Desso	11. DSM Niaga	12. Ecovative	13. Fairphone	14. Fat Lama	15. FLOOW2	16. Furnishare	17 GameStop
7. Limitations and challenges																		
1	Capital tied up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
2	Confidentiality for individual firms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
3	Cultural barriers	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
4	Customer type restrictions	0	1	0	1	0	0	1	0	0	0	0	1	1	1	0	1	1
5	Economic barriers	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Fashion vulnerability	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0
7	Higher risks for CBM	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	1
8	Increase of dependency to partners	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0
9	Lack of supporting regulation	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Mutual benefits for all partners	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
11	No problem owner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Operational risk	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0
13	Organizational barriers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
14	Partner restrictions	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	0	0
15	Product category restrictions	0	0	1	0	0	1	1	0	1	0	0	0	1	0	0	0	1
16	Requires technological expertise	1	1	1	1	0	1	1	1	1	1	1	0	1	0	0	0	1
17	Return flow challenges	1	0	0	0	1	0	1	1	1	1	1	0	1	0	0	1	1
18	Risk of cannibalization	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	Others, namely …	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-

Table 14. Case survey limitations companies 18-34

	18. Greenwheels	19. Interface	20. Kalundborg Symbiosis	21. Maersk Line	22. Mazuma Mobile	23. Mobility Carsharing	24. MUD Jeans	25. Park 20/20	26. PeerBY	27. Philips Lighting	28.REEPTechnologiesLtd.	29.RefuseVehicleSolutions	30. Replenish	31. Re-Tek	32. Rype Office	33. Splosh	34. The Plant
7. Limitations and challenges																	
1 Capital tied up	1	1	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0
2 Confidentiality for individual firms	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1
3 Cultural barriers	1	0	0	0	0	1	0	1	1	0	1	0	0	0	1	0	0
4 Customer type restrictions	0	0	0	0	1	0	1	0	1	0	1	0	0	0	1	1	0
5 Economic barriers	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0
6 Fashion vulnerability	0	0	0	0	0	0	1	-	0	0	0	0	0	0	1	0	0
7 Higher risks for CBM	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0
8 Increase of dependency to partners	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	1
9 Lack of supporting regulation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 Mutual benefits for all partners	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1
11 No problem owner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12 Operational risk	1	1	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0
13 Organizational barriers	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
14 Partner restrictions	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	1
15 Product category restrictions	0	0	1	0	1	0	0	-	0	0	0	1	1	1	0	0	0
16 Requires technological expertise	0	1	1	1	1	0	1	0	0	0	1	1	1	1	0	0	1
17 Return flow challenges	0	1	0	0	1	0	1	-	0	1	0	1	0	1	1	0	0
18 Risk of cannibalization	0	0	0	0	0	0	0	-	0	0	0	0	0	0	0	0	0
19 Others, namely …	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 15. Case survey CBMPs companies 1-17

		1. Aquafil	2. Auping	3. Autocraft Drivetrain Solutions	4. Black Bear Carbon	5. Braiform	6. Brocklesby	7. Caterpillar	8. Cisco	9. Coca-Cola Enterprises	10. Desso	11. DSM Niaga	12. Ecovative	13. Fairphone	14. Fat Lama	15. FLOOW2	16. Furnishare	17. GameStop
8. Circular business model patterns																		
1	Access and performance model	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0
2	Adopt a stewardship role	1	1	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1
3	Cascading and repurposing	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4	Industrial symbiosis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Maximize material and energy efficiency	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
6	Organic feedstock	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
7	Recycling/create value from waste	1	1	1	1	1	1	0	0	1	1	1	1	1	0	0	0	1
8	Refurbishment and remanufacturing	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0	1	1
9	Repair and maintenance	0	1	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0
10	Reuse and redistribution	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	1	0
11	Substitute with renewable and natural processes	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
12	Others, namely ...	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 16. Case survey CBMPs companies 18-34

		18. Greenwheels	19. Interface	20. Kalundborg Symbiosis	21. Maersk Line	22. Mazuma Mobile	23. Mobility Carsharing	24. MUD Jeans	25. Park 20/20	26. PeerBY	27. Philips Lighting	28. REEP Technologies Ltd.	29. Refuse Vehicle Solutions	30. Replenish	31. Re-Tek	32. Rype Office	33. Splosh	34. The Plant
8. Circular business model patterns																		
1	Access and performance model	1	1	0	0	0	1	1	0	1	1	0	0	0	0	1	0	0
2	Adopt a stewardship role	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
3	Cascading and repurposing	0	0	1	0	0	0	0	-	0	0	0	0	1	0	0	0	0
4	Industrial symbiosis	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
5	Maximize material and energy efficiency	0	1	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0
6	Organic feedstock	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7	Recycling/create value from waste	0	0	1	0	1	0	1	1	0	0	0	1	0	0	0	0	1
8	Refurbishment and remanufacturing	0	1	-	1	1	0	0	-	0	1	0	1	0	1	1	0	0
9	Repair and maintenance	0	0	-	1	0	0	1	-	0	1	0	1	0	1	0	0	0
10	Reuse and redistribution	0	1	-	0	0	0	0	-	0	0	1	0	0	0	1	1	0
11	Substitute with renewable and natural processes	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
12	Others, namely ...	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-

Appendix E | Interview Questions

Semi-structured interviews were held with two experts in the field. The researcher first explained the topic of the thesis, the (sub) research questions and the goal of the interview. The goal of the interview is that the expert knowledge of the interviewee will be used as a validation factor to the results of the case survey in Chapter 4 and to discuss issues on the transition to a more circular economy. Notes and full answers from the interviews can be requested from the author.

The following set-up for interview questions was used:

Interview questions

- Part 1: Opening questions
  - Can you tell me about your current research on circular business models?
  - According to you, what are interesting companies that are leading the CE principles?
  - Do you know the concept *(circular) business model patterns*? If not, I will explain more and give examples.

- Part 2: Pattern specific questions
  - Do you recognize the patterns that I have found?
  - Can you think of other patterns that are not listed?
  - When we are going through my results, what stands out for you?

- Part 3: Concluding questions
  - In my research I try to discover if and how knowledge of (circular) business model patterns can help the transition to a circular economy. What are your thoughts on this?
  - What more, in your opinion, is needed for a full transition to a CE? What is the role of companies in this?