Combining the digital and sustainable revolution

How organizations make successful use of data management in order to develop and realize business models for the Circular Economy.

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1. Introduction

1.1 Topic and problem

We are living in the year 2020. The world population has grown to over 7.5 billion people (UN, 2017) and is expected to grow further to almost 10 billion people in the year 2050. All these people consume foods, products and goods which are produced with certain resources. However, most resources are not renewable. Raw materials such as oil, coal or ore are expected to run out in the near future (Bebbington, Schneider, Stevenson & Fox, 2020). Therefore, it is necessary to re-evaluate our linear production methods, where production goes from raw materials to end product and from end product to garbage where it is usually burned (Korhonen, Honkasalo & Seppälä, 2017). The need for production methods where goods are re-used is widely acknowledged. In the linear economy, organizations produce goods which are thrown away once they are no longer needed. Companies aim on continuously improving current products, creating a continuous need for newer, better products. Circular production aims at the constant reuse of materials and parts of a product, with the same physical characteristics as it used to have. Adopting circular production instead of linear production has some challenges for organizations. It will be necessary to adopt new business models to make circular strategies work (Jonker et al., 2017). This is an ongoing process which will take time. Nevertheless, circular economy (CE) is a concept that can contribute to a more sustainable society in the near future.

Transition from linear to circular enabled by data management

CE differs fundamentally from linear economy. Therefore, when businesses want to change from linear to circular, serious challenges will arise. In a transition from linear to circular economy, more cooperation with parties in the 'value cycle' – the process of creating and delivering value - will be necessary (Jonker et al. 2017). This will undoubtedly require organizations to change their strategy and business models.

While the transition to CE is one trend that is happening in society, digitalization and data management is another trend to watch. 'The fourth industrial revolution' is taking place at the moment and is changing major processes within organizations and supply chains (PWC, 2016). Data management strategies and business models based on large-scale data could very well help organizations and supply chains in their transition towards circular economies (Jabbour et al, 2019). Data management strategies could contribute to both the development and the improvement of circular business models (CBMs).

Problem

The central theme in this thesis is how organizations make use of data management in developing and implementing CBMs. Organizations that are transitioning from linear to circular production face several challenges. They have to cope with questions on how to address the required changes in their business models and how to make use of digitalization and data management. It appears that not much research has been done on how organizations can make use of data management in the setting up and implementation of circular strategies (Jabbour et al 2019). A lot of research has been done about the transformation to more digital businesses. Also, a lot of research has been done on CBMs. However, little research has been done about the connection between the two. How can organizations make use of digitalization in their transition to more circular business models? This thesis investigates to what extent organizations can do this. It will investigate what organizations already do in their transition to circular economies, what factors influence the use of data management strategies when implementing CBMs and what the conditions are to be met in order to set up data management strategies that will help the organization move towards more circular production.

1.2 Theoretical positioning

Circular business models

CE can be defined as an economy constructed from societal production-consumption systems that maximizes the service produced from linear nature-society-nature material and energy throughput flow. This is done by using cyclical materials flows, renewable energy sources and cascading 1-type energy flows (Korhonen et al., 2017). It is widely acknowledged that the transition to CE raises many challenges for organizations. As discussed, business models of organizations in transition will have to be redefined (Jonker et al., 2017). There are three crucial elements that will have to be taken into account when organizations are transitioning from linear to circular business models: re-evaluation of the role and the place of raw materials; the conversion of products into services and the improved utilization of functionality (Jonker et al., 2017).

Service business models as an enabler of circular economy business models

As mentioned above, the conversion of products into services is one of the elements that has to be considered when it comes to transitioning to CE. The conversion of products into services can function as an enabler of CBMs. By transforming from ‘selling a product’ to ‘selling a

result', organizations can create value for customers without them having to own the product itself (Tukker, 2015). Creating service business models is not necessarily linked to CE, but the results have several similarities (Bressanelli, Adrodegari, Perona & Saccani, 2018). Service business models will create an incentive for organizations to design their products as efficient as possible, so that they can be used for as long as possible, creating value for the organization for the longest period of time. Data management can deliver a great contribution to service business models. Customer and usage data can improve the quality of both products and customer relations (Bressanelli, Adrodegari, Perona & Saccani, 2018), enhancing the lifespan of products and more efficient use of them.

Data management and circular economies

The mentioned three elements of transitioning from linear to circular economies could benefit from the use of data management strategies to make them work. However, it appears that research concerning the role of digital strategies and in particular data management approaches as part of new business models oriented towards CE is still in its infancy (Jabbour et al., 2019). More research to this combination can boost CE and therefore sustainability. CE can gain major benefits from the use of digitalization and data management strategies. Data management can be defined as an administrative process that includes acquiring, validating, storing, protecting, and processing required data to ensure the accessibility, reliability, and timeliness of the data for its users (Galetto, 2016). There are several ways in which data management can shape and improve business models for circular economies. Gathering and analyzing large bunches of data can help improve product design and create more efficiency in business processes. Examples of useful concepts are Product Service Systems (Antikainen, Uusitalo & Kivikytö-Reponen, 2018), Internet of Things (Rymaszewska, Helo & Gunasekaran, 2017) and digital collaboration in the supply chain. The required changes in business models force organizations to rethink their strategies and business models, including how to benefit from data management and how to set up data management strategies. CBMs backed by data management strategies could unlock great potential for organizations.

Research gap

There is a large amount of literature regarding the transition to more digital organizations. There is also a lot of literature available on how organizations can turn their business models into a 'more circular' one. However, little research has been done on what factors determine the application of data management strategies in CE and which conditions should be available or created within organizations to set up data management strategies. Shortly: how can data

management strategies in circular strategies be *successful*. The combination between data management and CBMs is still rather unexplored. How exactly does data management *actually* contribute to CBMs? The research that has been done on this topic were mostly literature studies or expert studies. Empirical studies are rather scarce. This thesis will empirically investigate how organizations make successful use of data management in their CBMs.

1.3 Research objective and research questions

The overall goal of this research project is to gain insight in how organizations make use of data management in order to develop and realize CBMs and how data management contributes to these CBMs. What possibilities are there for companies in making use of data and what challenges do they face in their transition from linear to circular production. What are the factors and conditions that make the development of data management strategies in CBMs a success? This thesis project will try to provide knowledge for organizations on how they can change their strategy and processes from linear to circular production and how data management can contribute to this. Therefore, the main research question is as follows:

How do organisations develop strategies to make successful use of data management in order to develop and realize business models for the Circular Economy?

In order to answer the main question, the following sub questions are formulated:

1. *What is the current situation and what are the problems organizations face in making use of data management for developing and implementing business models based on circular strategies?*
2. *Which factors determine the adoption of data management for developing business models based on circular strategies?*
3. *What are the conditions companies are implementing in order to successfully integrate data management into business models for a Circular Economy?*

The sub questions have been formulated in order to answer the main research question. The first question will describe the current situations and problems of organizations that are developing or have developed CBMs and how data was used to strengthen these models. How did they do this? What problems did they face in doing so?

The second sub question will describe the factors that determine the adoption of data management for developing CBMs. Which elements of data management strategies are fulfilled in order to make a combination between data management and CE? How can data management be used to improve CBMs?
The final sub question will focus on the conditions that are being implemented to successfully integrate data management into CBMs. What are the issues to be tackled to make use of data management in circular strategies? How can organizations make use of data management in their circular strategies and what measures do these organizations take to do so?

1.4 Practical and theoretical relevance

This study is important because it will try to help organizations make use of digital technologies to set up or improve their CBMs. When more knowledge is gained about this topic, it will be easier for organizations to become more circular. Research will be done on which factors do determine the adoption of data management for CBMs and what conditions are created to make the combination work. This thesis will provide insights in how organizations implement data management strategies that contribute to CE. This will enable organizations to focus on what is important for making use if digitalization in their CBMs, and will eventually contribute to a more sustainable society. The Dutch government has launched several websites and desks for entrepreneurs on how to become circular. However, those websites contain no information about the possibilities of data management. All practical tips of the government focus on how to implement CBMs. This thesis will try to strengthen circular strategies and business models by adding the component of data management strategies. In this way, entrepreneurs can eventually make use of this research project as a guideline on how to improve their circular strategies and make them 'future-proof'. This research project provides organizations with some direction on which data to gather and how to use this data to strengthen their CBMs.
This thesis is theoretically relevant because it closes a research gap. Many research has been done both on the transition to a more digital enterprise and on how organizations can implement CBMs. However, research on the combination of the two is scarce, and the research that has been done was mostly theoretical. Empirical research about what organizations *actually* do has not been found very often. This thesis will empirically research how digital technologies can be beneficial to the development and realization of CBMs. It will discover factors and conditions that determine the adoption and implementation of data management strategies for

the CE. The combination of data management and CE will contribute to the broader research on how to implement CE and how to improve or fasten this implementation.

1.5 Research approach

The first major step in this research is to create a theoretical base which defines all the terms given in the research question. Besides that, relations and insights presented in the academic literature will be discussed. It is necessary to find out exactly what is meant by circularity and get a clear view of what is meant when speaking of data management. What is already discovered by previous research on this material and how can it relate to the research questions posed in this thesis. After this, a conceptual model is developed which depicts the research question. Then the research methods are defined. This research will take a qualitative approach as a starting point. This because it is difficult to answer the research question with statistical analyses. Instead, by doing qualitative research, there is tried to get insight in how certain companies are using data when becoming more circular and what is the common factor in their approaches. What challenges did these companies face and how did they cope with them? How did those companies make use of data management in these matters? What problems did they face in doing so? These questions are answered by conducting semi-structured interviews with organizations who are involved in transitioning to CE in some way. During the interviews there was tried to get a better view on how those organizations use data to implement circular strategies.

2. Theoretical background

2.1 Introduction

The second chapter of this thesis will give a description of the existing literature about CE and data management. It will deep dive into the major concepts that are stated in the research questions and will try to give some body on how this topic is framed in current academic literature. Which knowledge has been found on the topic of data management to develop and realize CBMs? Which relations have been discovered between certain concepts and what has been the cause of those relations?

In order to get a better understanding of the topic of this research, the most important elements and relations between elements of this research question will be explained by existing academic literature.

The research questions have led to a few topics that will be further explained in this literature chapter. This will clarify the overarching research question and will make it easier to do the actual research in further chapters. The major concepts that will be explained in this chapter are the following:

- why organizations should change from linear to circular;
- transition from linear to circular: barriers and the enabling role of data;
- integrating data management in circular business models: state of things and possibilities;
- which factors determine the adoption and the success of data management in circular business models.

These concepts will be explained by existing literature. There are five articles that have been considered the most important in providing this literature review. Those articles are summarized below, indicating the relevance and the research gap that is stated, based on the article.

Article	Relevant insights	Knowledge gap
Jabbour, de Sousa Jabbour, Sarkis & Godinho Filho (2019)	3 key aspects of CE: stakeholders, business models and 4 V's of large data management.	No clear link between how large data management can contribute to setting up CE business models (with ReSOLVE)
Nobre & Tavares (2017)	Big data and IoT applications on CE: a literature review. Provides insight in the amount of	Most research projects reviewed were based on 'imagining the possibilities' rather than 'actually

	scientific articles published over the past years.	developing case studies based on already established programs for benefits measuring'.
Nobre & Tavares (2020)	Assessing the role of Big Data and IoT on the transition to CE, using the ReSOLVE model. This study proposes a preliminary framework for IT capabilities, built on the ReSOLVE framework, to be used by IT professionals in order to understand and assess their organization's gaps for the transition to CE.	The study bases its results only on present academic literature. There is no empirical content to validate the framework developed.
Lieder & Rashid (2016)	Towards CE implementation. It proposes implementation strategies for CE. It provides a framework where institutions impose CE from a top-down approach, whereas organizations do this bottom-up.	This article does not consider the IT/Data aspects which will accompany CBMs in succeeding.
Bressanelli, Adrodegari, Perona & Saccani (2018)	This article focuses on how digital technologies such as Big Data and IoT enable a transition from linear economies to CE. It provides 8 functionalities (within CE) that can be enabled by IT services as mentioned above.	This article focuses on the fact that IT-services enables linear functionalities. Nevertheless, it does not consider how IT services enable CE. Besides, it only considers usage-focused business models.

Table 2.1: key articles

The articles will be described more detailed throughout this chapter. Some of the articles are based on literature reviews. This opens up the possibility to empirically test the statements from those articles in this research project.

2.2 Why organizations should change from linear to circular

Linear and circular production strategies

Linear production is an old-fashioned way of producing. It aims to produce as much as possible at the highest speed possible. Profit comes from the throughput of materials where value is added (Stahel, 2018). Simplified: transforming raw materials into end products and selling

them. Profitability lies in the fact that the liability for damages to or end of life of products lies almost entirely with the consumer. Once the products are used up, consumers will buy new goods which increases turnover of production companies. Linear production works through the take-make-waste principle (Veleva, Todkin & Bodorova, 2017). After products are disposed, the remaining value of the products is completely lost.

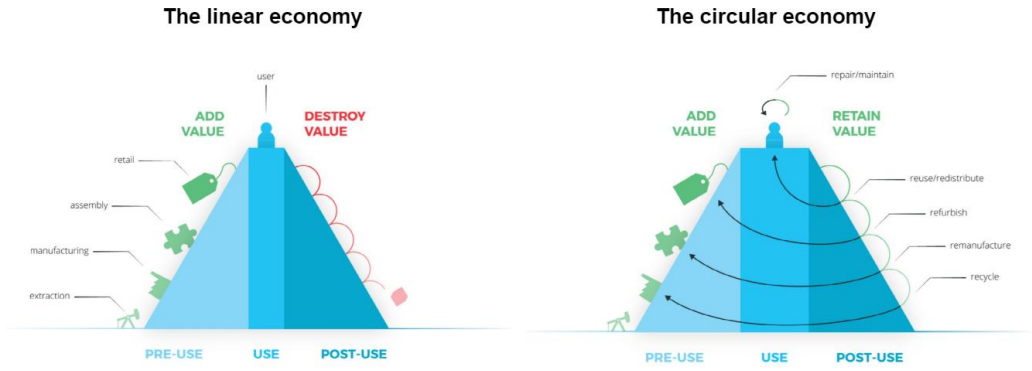

Figure 2.1: difference of the linear and circular economy (Achterberg, Hinfelaar and Bocken, 2016)

Circular production strives to reuse all components of products on the same economic level. By doing this, all the value within a product will be preserved (Korhonen et al., 2018).

Importance of a circular economy

The consequence of depletion of natural resources it that it will lead to eventual scarcity of those resources, with the inevitable consequence of prices to rise. More and more people agree that linear production will not be a viable production system on the long-term. Therefore, it is necessary that organizations realize the need to transition to CE. The problem is that most organizations usually focus on profit. Therefore, it is necessary that evidence will be provided that CE will not only lead to more sustainable production, but will also lead to profitable production (Lahti, Wincent & Parida 2018).

The two most important economic reasons to change to CE are the 'profit pool' provided by CE and the fact that the benefits of CE will tackle some major strategic challenges that organizations face (Ellen MacArthur Foundation, 2013).

By 'jumping in the profit pool' is meant that organizations gain large profits by using elements of CE. An example of this is the collection of products in the end-of-life stage. When organizations collect these products and reuse them, this could deliver a major profit rise of those companies.

There are some major strategic challenges for organizations that could be tackled by CE. Possibilities within the CE are an intensely reduced cost price of products (through reuse),

increasing customer loyalty (by servitization) and the solution of increased supply risks, by (almost) completely reusing materials and resources (Ellen MacArthur Foundation, 2013).

The importance of data management in organizations, regarding CE

The digitalization of industries and organizations is known as 'the fourth industrial revolution' or as 'Industry 4.0' (PWC, 2016). Industry 4.0 is all about the generation, analysis and communication of data. The term 'fourth industrial revolution' stresses the importance of this development in industries. Over 80% of the companies surveyed in the Global Industrial Survey of 2017 (Stanton & Chase) regard industry 4.0 as important for their organizations. Executives of organizations are aware of the fact that industry 4.0 will undoubtedly be a part of their businesses in the (near) future.

In order to keep up with innovations and developments in the field, organizations will have to innovate themselves too. Organizations will have to make changes in all parts of their value chain to comply with industry 4.0. This will require changes in skills and capabilities, but also in the infrastructure of organizations and the value chain (PWC, 2016).

As mentioned, industry 4.0 is all about data. According to PWC (2016), industry 4.0 is driven by three elements: digitalization of value chains, digitalization of product and service offerings, digital business models and customer access. Literature concerns data analytics as a core capability of organizations (Akter et al., 2016). Organizations will have to design their value chain in such a way that it can profit maximally of the new digital era.

How can CBMs benefit from Industry 4.0? Not much research has been done about the direct link between Industry 4.0 and CBMs. It is clear that Industry 4.0 unlocks a lot of possibilities for innovative organizations, so it will be plausible that it could also do so for organizations working on CE.

2.3 The transition: success factors, barriers and the role of data management

Success factors and barriers in transitioning to CE

What determines the successful implementation of circular strategies? Lieder & Rashid (2016) mention the need for transformation of economic structures and business rationales, change of product design and the and the manufacturing process. They emphasize the need for change in the nature of the economic structure. The assumptions within this structure need to change from 'open systems with unlimited resource supplies' to a 'closed system with limited resource supplies'. The focus here should be on the extension of product lives and minimizing material

flows and environmental harm. This should lead to an economy in line with resource limitations.

Moktadir et al. (2020) define six critical success factors for a CE. The three most important success factors are leadership and top management commitment, practices of reverse logistics and capacity building and information management for a CE. The last factor stands out, as data management is a form of information management, therefore part of this research project.

Even though much attention has been given to transforming to CE by policy makers (e.g. Rijksoverheid, 2016), its actual implementation is still not really starting to happen (Stahel, 2016). Several barriers have been mentioned, of which a few are broadly acknowledged.

There are several distinctions made between certain barriers to CE. Kirchherr et al. (2018) distinguish four categories of barriers for a transition to CE: cultural, regulatory, market and technological barriers. These categories can be divided into soft and hard barriers (de Jesus & Mendonca, 2018). In absolute numbers, 15 barriers are defined (Kirchherr et al., 2018). The four categories are discussed here. Hard barriers are technical and market barriers, soft barriers are cultural and regulatory barriers. Soft barriers are considered the most constraining (de Jesus & Mendonca, 2018).

Cultural barriers to CE consider both internal culture and external culture. Consumers are simply not ready for CE, because 'people want to *own* products' (Ranta et al., 2017). Besides consumer culture there is company culture. Organizations always consider their environment. The most important environmental actor is the customer. In that perspective, it does not raise any questions that companies 'follow' their customer in the organizations' behavior (Friedman, 1970). Therefore, if customers are not ready for CE, why would an organization be?

Market barriers are the second category of barriers to CE. The two most concerning challenges in this category are the low prices of virgin materials and high upfront investment costs (Kirchherr et al., 2018). Negative side effects of fossil fuels are not included in the price of those fuels. Non-recycled raw materials are mostly cheaper, making it difficult for recycled resources to compete with them. Besides this, high upfront investment costs scare organizations to make a transition to CE.

The third barrier is regulatory. Laws often conflict with principles of CE (Kirchherr et al., 2018). Taking away such barriers is necessary for a successful transition.

The last category of barriers are the technical ones. Technical barriers are mentioned the most in the academic literature when it comes to challenges faced by the CE (Kirchherr et al., 2018). Technical barriers include not only factors concerning the existence of appropriate technology,

but also technology gaps such as the lag between processes and product development, and the lag between invention and production (de Jesus & Mendonça, 2018).

Data management as a catalyst for enabling circular economy

As was stated before, data management can be a crucial enabler of the circular economy. How can data management be helpful in the transition from linear to circular economy? To give an answer to this question, it is needed to have a clear view on what is meant by 'data management'. As earlier mentioned, Industry 4.0 is all about data and the way it is managed. Data management will be one of the core capabilities of organizations making use of industry 4.0 (PWC, 2016). According to Kang et al. (2016), there are four core technologies of Industry 4.0: Cyber physical systems and Big Data, Cloud Manufacturing, Internet of Things (IoT) and Additive Manufacturing. These are the major digital technologies based on data that will take the lead in 'Industry 4.0'. Therefore, these four technologies will be considered as the technologies that could be enablers of the CE. The two most important ones are IoT and Cyber physical systems and big data. How could these technologies contribute to the transition to CE? Collecting and analyzing large amounts of data about the physical state and the use of products could result in valuable information about those products (Jabbour et al., 2018). This data can help to overcome the barriers that are stated below.

Barriers for data management strategies regarding CE

When organizations want to make use of data management for their CBMs, it is necessary that they will have a strategy that focuses on data management for the CE. Data management can offer a lot of chances for CBMs, but in order to unlock these chances organizations need to have a clear vision on their strategy. There are several barriers that hinder the implementation of data management strategies. Based on studies of Tabesh, Mousavidin & Hasani (2019) and of Shubhangini & Singh (2019) the most important barriers are explained below. They can be categorized as cost barriers, technological barriers and cultural barriers.

The first category of barriers is cost barriers. Setting up a data management strategy requires large and new investments in technology: the setting up of so called cyber physical systems (Subhangini & Singh, 2019). These cyber physical systems are the link between physical products and the digital information that is gathered. Setting up such systems requires investments in technology and skills. Managers are hesitant to make such investments, as they are unsure whether these investments will pay of or not (Rajput & Singh, 2019).

The second category of barriers is technological barriers. There are three major technological barriers stated for the implementation of data management regarding CE: insufficient digital

infrastructure, lack of processing capacity and concerns regarding data ownership and privacy.
The first technological barrier is the digital infrastructure. In order to make use of data management in CBMs, organizations need to have an infrastructure to acquire, store and process the data (Shubhangini & Singh, 2019). It is also needed to connect applications to a digital system. Organizations need to invest in this infrastructure, which connects this barrier to the barrier of investment costs.

The second technological barrier is the lack of processing capacity. When organization gather large amounts of data from their products, this data needs to be processed in order to gain advantage of it. To do this, skilled personnel is needed which is capable of analyzing data: data scientists (Tabesh, Mousavidin & Hasani, 2019). Currently, the demand for data scientists is a lot bigger than the supply. Two-third of organizations searching for qualified data scientist struggle with fulfilling their positions (Boulton, 2015). If organizations will have no sufficiently skilled personnel, the potential of data cannot be unlocked.

The final technological barrier is the struggle with data ownership and privacy. Gathering large amounts of usage data comes with many privacy regulations with which organizations need to comply. Several examples of illegal data sharing/selling have gotten attention over the last years (e.g. the Facebook and Cambridge Analytics scandal). Therefore, organizations are required to comply with all regulations, creating more investment costs (Kottasova, 2018).

The third category of barriers for data management strategies for a CE are the cultural barriers. If organizations want to profit from data management strategies, it is necessary that they have a data driven culture. A data driven culture means "the extent to which organizational members (including top-level executives, middle managers, and lower-level employees) make decisions based on the insights extracted from data" (Gupta & George, 2016: p. 5). Therefore, lack of data driven organizational culture can lead to members making poor decisions while there are data management strategies available. Organizational members may rely on their management experience, rather than on the objective information provided by data, leading to poor decision making.

The second cultural barrier is tightly linked to data driven culture: the inability to create a vision based on data management. Top executives require sufficient knowledge about data management. If this is not the case, difficulties rise in creating a data-oriented vision, which will cause the organization to lack clear direction in their data management strategies (Tabesh, Mousavidin & Hasani, 2019). It is needed that top managers embrace the potential of data driven culture and strategies, otherwise the implementation within organizations will fail.

Practical implementation of data management strategies for the CE

There are three features that organizations need to consider when implementing data management strategies for the CE: commitment and support, communication and coordination and familiarity with systems (Crittenden & Crittenden, 2008; Tabesh, Mousavidin & Hasani, 2019).

The first feature is commitment and support. In order to successfully implement data management strategies, middle and higher managers should show commitment and support in the implementation. This is necessary to overcome the barriers that are earlier mentioned.

Secondly, it is very important that everyone within the organization is aware of the purposes and goals of the data management strategy. This requires communication about these purposes in all stages of the strategic process. If a data management strategy is clear to all members of an organization, the chances of successful implementation are bigger. It will create shared vision and commitment among members (Chen, Chiang, & Storey, 2012).

The final feature is familiarity with systems. Like already mentioned before, one barrier to data management for the CE is lack of vision and data driven organizational culture. Part of this data driven culture is that employees in an organization are familiar with the systems and infrastructure that is used to perform data analytics. Managerial misunderstanding of big data is one of the main reasons for a data management strategy to fail (Ross et al., 2013). Therefore, in order to successfully implement strategies, is it necessary that managers are familiar with systems. This will make them understand the underlying goals of the strategy (Tabesh, Mousavidin & Hasani, 2019).

However, in order to be able to implement data management strategies for the CE, it is necessary that organizations have a CBM. If a CBM is not available, data management can logically pay no contribution to these models. Paragraph 2.4 will discuss the business model state of things for the circular economy based on the ReSOLVE model (Ellen MacArthur Foundation, 2015). This model gives good indications on how data management can actually contribute to certain aspects of CBMs.

The practical implementation of CE requires not only action from organizations, but also from public institutions. The reason for this is that both parties have different motivations in implementing CE. Institutions' main incentive is to raise awareness about sustainability issues and the societal benefit of industrial activities (Lieder & Rashid, 2016). This leads to strict control of organizations. Organizations' primary focus is on economic benefits and growth.

They might have environmental concerns too, but due to heavy competition it is more difficult to consider the environment. Therefore, in order to make CE work, a different approach for both parties is required. The task for the governmental body is to support CE by means of legislation, creation of infrastructure and raising social awareness among society. Governments could stimulate CE by for example tax measures. Infrastructure could be facilitated by creating collection lines. Social awareness could be raised among customers by creating educational programs, describing the need for CE.

2.4 Integrating data management in circular business models: state of things and requirements

From linear to circular production strategies - reengineering business models

When organizations are changing from linear to circular strategies, it is needed to transform their business models. In order to do so and how it is actually done, it is therefore necessary to know what is actually meant by the term 'business model'. Very shortly, business models can be seen as 'a story that explains how a business works' (Magretta, 2002). More specific it is referred to as 'the explanation of the value chain of an organization' (Porter, 1985). CBMs should include 'how a *circular* business works'.

What types a CBM? The key difference between linear business models and CBMs is, logically, circularity. The base of CBMs is the element that there is no leakage of raw materials anymore (Jonker et al., 2017). While linear business models dispose materials at the end of life, CBMs strive to take out this end of life phase of products by reusing or recycling them. There are three key elements that distinguish CBMs from linear business models. Those three elements are:

- re-evaluation of the role and the place of raw materials;
- the conversion of products into services;
- the improved utilization of functionality (Jonker et al., 2017).

The first element of CBMs entails that raw materials will no longer be valued as 'disposable'. The cycle of raw materials needs to be closed to become circular. Resources will no longer be seen as temporary and replaceable but as something that will be in production for as long as possible (Jonker et al., 2017).

The second element is the conversion of products into services. This is an addition to the first element because it is an incentive to 'close the chain'. Any product can be converted into a service. The most important advantage is that the ownership of those products will no longer belong to the user, but belongs to the service provider. The consequence of this is that the

producer has a strong incentive to produce goods as sustainable as possible. The longer a product can be used, the longer it can provide revenue to the company (Jonker et al., 2017).
The third element of CBMs is the improved utilization of functionality. Improved utilization of functionality means that the actual function of a product has to be used more efficient (Jonker et al., 2017). This element can be fulfilled by the earlier mentioned product-as-service. Sustainability researchers argued that if one were to focus on final user needs or the service a user wants rather than the product, it would become much easier to design need-fulfillment systems with radically lower impacts. (Tukker, 2015).

ReSOLVE model

The ReSOLVE model provides six pillars on which CE business models can concentrate (Ellen MacArthur Foundation, 2017). Those pillars are possibilities for organizations to base their business model on. The ReSOLVE model is chosen as the base model for this research, because it recognizes the need of digital technologies in CBMs (Nobre & Tavares, 2020). It helps to unravel CBMs and to assess to what parts of this business model which forms of data management can be useful. All of the pillars of the ReSOLVE model increase the utilization of physical assets, prolong their life, and shift resource use from finite to renewable sources (Ellen MacArthur Foundation, 2015). Shortly, these pillars contribute to CE. They can be used separately, however, each action accelerates the other. Therefore, the more pillars are used, the faster and easier the transition to CE will go. The six pillars fulfill the elements that are provided by the research of Jonker et al. (2017). With these six pillars, it will be possible to create business models based on the principles of the CE. Data management can contribute to each of the six pillars in its own way. This makes it possible to assess the possibilities of digital technologies for CBMs (Nobre & Tavares, 2020). By taking apart the elements, it is possible to get an in-depth view on how different aspects of Industry 4.0 (i.e. IoT and Big Data) contribute to the elements of the ReSOLVE model. The six definitions of this model are discussed below:

‘Regenerate’. It stands for the change to renewable energy and materials. Besides this, waste should be turned into resources of energy.

‘Share’. It stands for the earlier discussed ‘use over ownership’. Products are no longer sold, but are hired and taken back once they are used up. Coordination is key in this matter, possibly facilitated by IoT (Ellen MacArthur Foundation, 2015).

‘Optimize’ means increasing performance of products. Remove waste in production and supply chain. Data and IT can be helpful in this matter. Providing sensors to products could result in valuable data about them, improving efficiency and product design.
‘Loop’ means remanufacturing products, recycling and reusing as much of the materials on the highest economic level for as long as possible.
‘Virtualize’ means the direct and indirect dematerialization of products and services. Digitalization will have a large role in this. Think of the replacement of DVD’s and CD’s with computer files. Besides this, indirect virtualization will also contribute to more CE, for example by digital shopping.
‘Exchange’ is literally the changing of old and non-advanced goods with new advanced goods. Those goods should logically be in line with the circular premises stated above. If this is done constantly, eventually all the linear produced goods will be banned, resulting in a circular society.
As seen in the explanation of the ReSOLVE business models, there are several places where IT and data management could be a great enabler of certain processes. Mainly IoT and Big Data can influence the speed and success rate of the adoption of CBMs (Jabbour et al., 2019). The major elements are explained below, after which they are connected to the ReSOLVE model.

Enabling role of IT and data management in CE business models

How can IT and data management contribute to businesses trying to become more circular? Data management and IT are becoming more and more important in this digital era. It could deliver great opportunities for companies who strive for more circularity. Digital technologies bring chances for better and more efficient use of resources, or in the transition from products to services (Neligan, 2018). Digitalization can help organizations ‘close the loop’. However, there are many challenges in designing a digitalized circular strategy. What is the enabling role of IT and data management in CE business models? Several digital technologies and how they can enable CE will be discussed here.

Big data

Big Data is one of the key new digital technologies that can be used for CBMs. Big Data can be defined by using the 4 V’s of Big Data: volume, variety, velocity and veracity (Marr, 2015). The difference between Big Data and ‘data’ is of course, first of all, the volume. Big Data allows massive amounts of data to be generated continually. Besides this, the variety of data is different. Big Data allows to generate all different sorts of data, not only textual material. Images, videos, voice records and different types of data can be generated by Big Data. Big

Data allows to analyse data before it is even stocked. This extremely fast analysis of data is accounted by velocity. Finally, the quality of the data is really high, meant by veracity. The 4 V's of big data can be linked to all the elements of CBMs, making them a major enabler of those CBMs (Jabbour et al., 2019). There are various opportunities for Big Data to contribute to CBMs. Some examples are optimizing components design based on Big Data analytics, product lifecycle management by Big Data or improving the usage rates of products by Big Data (Nobre & Tavares, 2020). Shortly: Big Data can provide organizations with valuable insights about product design and usage, creating possibilities for organizations to strengthen their CBMs.

Internet of Things (IoT)

Another major development in digital technologies is the Internet of Things. IoT is an emerging technology that enables data acquisition, transmission and exchange among electronic devices and targets enabling integration with every object through embedded systems (Xial, Yang, Wang & Vinel, 2012). It has three main components: asset digitization, asset data gathering and computational algorithms to control the system formed by the interconnected assets. IoT can be used in any activity involving data monitoring and control, and information sharing and collaboration (Nobre & Tavares, 2020). IoT can contribute to CE because it creates the possibility to make products 'smart'. Equipping products with all sorts of sensors makes it possible to generate real-time data about the state of products and the way they are used (Rymaszewska, Helo & Gunasekaran, 2017). IoT can enable CE through various ways, mainly for circular aspects like asset sharing and virtualization (Jabbour et al., 2019), but can also improve product lifecycle management. IoT can contribute to improvement of product design and predictive maintenance. This contributes to CE because products will last longer and could be used more efficient (Nobre & Tavares 2020).

Product service systems

One of the key elements of digitalization and circular economy is the 'transformation from products to services' (Jonker et al., 2017). Product service systems are defined as follows: 'a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer needs' (Tukker & Tischner, 2006). Product service systems are not directly circular, but circular economy and product service systems aim to reach the same goals. That is why they are combined fairly easy. Data management strategies are rather easily implemented in product service systems, because data management in product service

systems can be used both for product innovation and to improve customer service (Antikainen et al., 2018).

What are the elements in product service systems, that data management could effectively improve? Data management gives the opportunity to organizations to actively and effectively monitor the way products are used. Like already mentioned, IoT allows organizations to equip their products with all sorts of sensors, continuously providing information to those organizations about the state of the product (Rymaszewska, Helo & Gunasekaran, 2017). A consequence of smart products is that they are able to be updated with newer software every now and then, preventing them from becoming outdated (Pialot, Millet & Bisiaux, 2017).

Contribution of data management linked to the resolve model

How can digitalization contribute to CBMs in a concrete manner? Some propositions have been made on how to link Industry 4.0 to sustainable business models, more specific CBMs. CBMs focus on the conversion of products into services, the re-evaluation of resources and the improved utilization of functionality. These elements are translated in the ReSOLVE model. Below can be found a general diagram on how different elements of Industry 4.0 can contribute to certain aspects of the ReSOLVE model. The diagram is based on the findings of Jabbour et al. (2018) and Bressanelli, Adrodegari, Perona & Saccani (2018).

Resolve model	Type of digitalization	Possible purposes
Regenerate	IoT, Big Data	Reduce resource consumption by increasing efficiency in product use and maintenance by analyzing data provided by smart products.
Share	Big Data	Connect users of products and share information through e.g. websites. Increase service levels, more added value. More efficient product use by gathering usage data.
Optimize	IoT, Big Data	Optimize product design, use and maintenance by intelligent sensoring.
Loop	IoT	Creation of material passports, recycling worn out products.
Virtualize	IoT, Big Data	New initiatives in product sharing, personalized product design and production.
Exchange	Additive Manufacturing	3D-printing of spare parts.

Table 2.2: purposes of digital technologies in the ReSOLVE model

Collaboration in the supply chain

All measures stated above see at the products of organizations. Data management can result in enormous improvements in product management and end-of-life strategies for products. However, there are also lots of possibilities within networks of organizations. Organizations need to cooperate with each other to foster circularity. Digitalization can contribute to such cooperation. Supply chain networks need to cooperate with each other to fully make use of the opportunities of CE. Big Data and IoT enable several possibilities for more or better collaborations in the supply chain. Within operations and supply chain management, Big Data has the potential to bring improved productivity, competitiveness and efficiency, as well as to help in decision making with regard to pricing, optimization, operational risk reduction and improved product and service delivery (Papadopoulos et al., 2017). The topic of collaboration in the supply chain is not very broadly covered in this research project. Future research can investigate the importance of this subject.

2.5 Factors that determine the adoption and implementation of data management for CBMs

What are the factors that determine the adoption and implementation of data management strategies for the CE? These two elements are discussed in this chapter. No literature was found on what factors adopt data management strategies specifically for the CE. General adoption factors for data management strategies have. This will be discussed below, where specific adoption factors related to the CE are to be further elaborated on in chapter 4. Implementation factors (or critical success factors (CSF)) have been discussed for data management strategies in CBMs and will be described below too.

Adoption factors for data strategies

What factors determine the adoption of data strategies? In the previous paragraphs has become clear that the potential of industry 4.0 for the CE is enormous. It can contribute to basically all aspects of a CBM and can therefore be very useful in setting up and strengthening CBMs. Like mentioned, no specific research has been found on the adoption factors of data strategies for the CE. Therefore, adoption factors for data strategies in general will be discussed here. They might be applicable to data management strategies for the CE.

Adoption factors for a data strategy can be divided into three categories: innovation characteristics, organization characteristics and environment characteristics (Sun, Cegielski, Jia

& Hall, 2016). Innovation characteristics have to do with the possibilities and costs of the investment: (the extent of) competitive advantage and the costs of adopting a data management strategy. Organization characteristics are internal factors that determine the adoption: human and technical resources within the organization, organizational culture and management support. Finally, there are environment characteristics, factors from outside the organization: security and privacy, ethical environment and legislation that enables/inhibits the use of data.

Implementation conditions for data management contributing to CE

There are some factors considered to be crucial to make data management for CBMs a success. They will be further discussed in chapter 4. De Sousa Jabbour, Jabbour, Foropon & Godinho Filho (2018) have described what they call CSFs for data management and environmentally sustainable manufacturing. CSFs can be understood as organizational actions necessary to ensure success and competitiveness, thus supporting a company's organizational change processes (Rockart, 1978). These critical success factors could be the key to achieving a successful combination of data management and circular economy. The CSFs in research of Jabbour et al. (2018) are derived from a literature analysis rather than empirical research. Therefore, they are indicative to this research project.

CSF	Explanation
Management leadership and commitment	Management leadership and commitment is needed for successful implementation. Capable and inspiring managers can lead the way and create an environment where strategic change can thrive (Dong et al., 2009).
Successful change management	Successful change management can predict the success of the adoption of strategic change (Jones et al., 2005). Therefore, managing change successfully will strengthen strategic change.
Strategic alignment	The fit between adoption of the data management strategy and organizational goals should be as good as possible. With other words: the way and the type of data that is used should be in line with the goals of the organizations.
Skills and training	In order to fully use the potential of data management strategies, organizational members should have sufficient knowledge about both data management and CE. This requires training for these members to make it a success (Waibel et al., 2017).
Teamwork	As data management overarches different levels of the organization, more teamwork is

	needed among organizational members to make these strategies work (Stock & Seliger, 2016)
Culture	In order to change smoothly, the organizational culture should be 'data driven' (Gupta & George, 2016).
Communication	This factor considers communication in the supply chain. Communication and cooperation in the supply chain is crucial for the combination of data management and CE, but it not broadly considered in this thesis.

Table 2.3: CSFs of data management for CBMs.

Since IT/data management and CE are both quite innovative projects, there are several challenges and barriers that have been discussed. The challenges for the transition to CBMs consider things as changing organizational culture, changing customer behavior and overcoming technological challenges.

Setting up digital strategies comes with their own data-specific challenges. Questions to be asked in setting up digital strategies are 'Do you need structured or unstructured data, or (ideally) a combination of the two?' 'Can you achieve your goal with internal data alone, or do you need to supplement your company data with external data (for example, social media data, weather data, etc.)?' 'Do you already have or can you quickly access the data you need?' 'If not, you need to set up a way to collect the appropriate data. What data collection method will you use?' (Marr, 2017).

2.6 Conceptual model

The research questions aim to discover how organizations develop strategies to make use of data management in the setting up and implementation of circular strategies and what challenges they face in doing so. The conceptual model corresponding to this research question is shown and explained below.

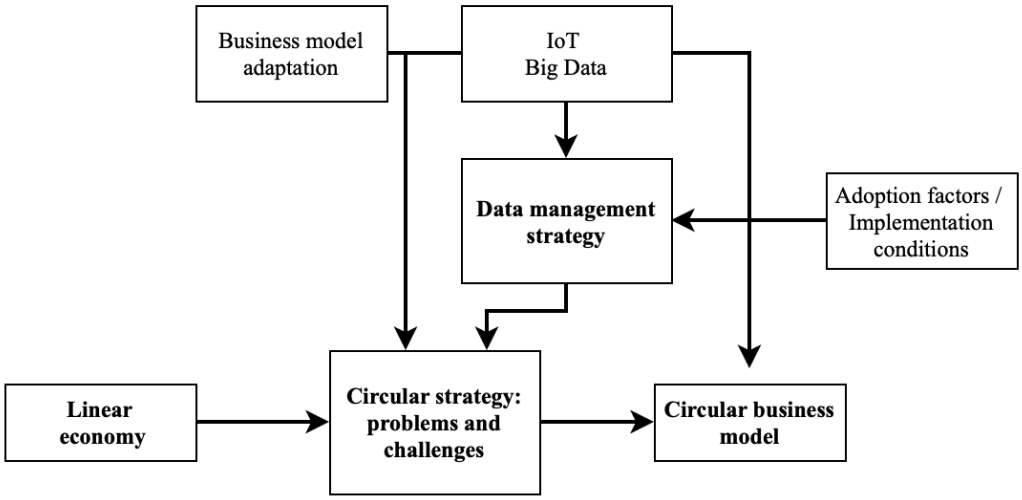

Figure 2.2: conceptual model

When organizations produce in a linear way, this corresponds to certain business models and strategies. This is not different for circular production. However, the transition phase from linear to circular economy come with certain processes that will be researched through this project. Organizations require circular strategies which could be supported by data management. How do companies adapt their business models, how is the transition from linear to circular performed and how can data management strategies contribute to this transition? IoT and Big Data are the two most important digitalization components that are researched. These two elements are to be included in a data management strategy which should be supporting the circular strategy, eventually leading to a CBM. IoT and Big Data could also be directly used in the CBM, because they could strengthen certain aspects of those models. Therefore, IoT and Big Data point in two directions. On the one hand it can contribute to the digital strategy affecting the circular strategy, on the other hand it can also be a part of the eventual CBM of organizations. Besides this, there are certain factors that determine the adoption of data management in developing CBMs. There are also conditions that need to be met to successfully integrate IT and data management into CBMs. These factors and conditions affect the data management strategy, therefore the arrow draws from these factors/condition to the process of a data management strategy. The problems, challenges, adoption factors and implementation conditions that come with a data management strategy supporting CBMs have been discussed in this chapter. There will be more elaboration in chapter 4, where the results are presented.

3. Methodology

3.1 Overall research approach

The overall research approach is based on the research question. In order to be able to answer the research questions, qualitative research has been performed. Interviews have been taken at several organizations that are working on a transition to CBMs. Within these organizations, semi-structured interviews have been held with people responsible for the strategies of organizations, but also with IT-personnel. This has been done to discover the possibilities of data management for CBMs.

The research has been performed by the principles of qualitative research (Draper, 2004): it is an inductive process where textual data generated by interviews has been analyzed. The interview codes have been derived from the data itself.

The interviews have provided lots of textual data on how organizations made use of data management to develop and realize CBMs. The organizations have some elements in common that have occurred in the realization of their CBMs and how they made use of data management in their business models. The nature of qualitative research makes it more difficult to generalize findings to a larger group (Mason, 2017). However, concepts discovered in the interviews might be applicable to other organizations too, providing future research possibilities.

In total, seven interviews have been performed in six different organizations. The way organizations were selected and a description of the interviewees is given below.

3.2 Research design

Qualitative research methods focus on data that is, contrary to quantitative research methods, based on words and language (Bleijenbergh, 2015). This research focuses on organizations. An organization is defined as a cooperation between groups of people aiming for a common goal (Bleijenbergh, 2015, p. 13). With qualitative research methods, it is more difficult to make judgements about relationships between specific variables and how strong those relationships are. However, qualitative research can give a good overview on how different factors relate with each other in certain patterns. This is called analytic generalization (Mills, Durepos & Wiebe, 2010, p. 21). More on analytic generation will be given in paragraph 3.5.

The research question does not imply certain relationship between specific variables. There is no specific variable that will have a major impact on why organizations make use of data management when setting up or implementing circular strategies. There are probably many

ways organizations do this and there are many incentives why they do so. These will be explained in chapter 4.

Interview questions

The interview questions have been based on the research questions that are the base of this research project. The first questions were based on the CBM of the organization. These questions were formulated to get an overview of how far organizations were in their transition to a more circular economy. After this, organizations were asked about the way they were using digital technologies in their business models. Both IoT and Big Data were mentioned beforehand to assess whether organizations were familiar with these technologies and to what extent they were used. Interviewees were asked about the measures taken to make use of digital technologies and how they were taken by the organization. Besides this, there was asked about the problems organizations faced in the use of digital technologies for their CBMs.

Company selection

The organizations interviewed were selected by their business models. Because the research question aims to investigate how organizations make successful use of data management strategies in the development or implementation of their CBMs, the first criterium of the company selection was that organizations actually had to be working a circular business model. There are several different CBMs, but the baseline of circularity is the reuse of materials on the same economic level. This was the first criterium for organizations to be selected. All of the organizations were working on circularity. Not necessarily primarily and only, but the organizations had to make use of it. In order to be able to connect digitalization and CE, it was of course necessary that organizations made use of digital technologies to some extent. Because this research investigates the possibilities of digital technologies for the circular economy, there were no further specifications on the degree of digitalization in the organizations. Because some of the interviewees preferred not to be mentioned by name, all organizations researched have been anonymised.

3.3 Sample, data sources and measures to be used

The sample of this research project are organizations, more specific people within organizations responsible for innovation, strategy, design or IT-department of the organization. Below can be found a table with the interviewees of this research.

Organization no.	Function of the interviewee	Type of organization	Interview duration
1	International Sales Director	Provides hatchery solutions	40 minutes
2	Innovation Manager	Production of kitchen and consumer electronics	44 minutes
2	Business Information Manager	Production of kitchen and consumer electronics	37 minutes
3	Business Development Manager	Mattress and bed production	24 minutes
4	Innovation & Technology Director	Providing water solutions	30 minutes
5	Innovation Process Manager	Contraction company	30 minutes
6	Director of Operational Excellence and External Affairs	PET-bottle recycling company	33 minutes

Table 3.1: interviewee overview

The research project has an inductive approach. This means that the central concepts have not been defined. The previous chapter has given a theoretical base, but the actual answering of the research questions will not be done with hypotheses or propositions. The theoretical base will help find the answers to the research questions, but it is not written to deny or approve any of the research questions. The research questions are there to build more theoretical knowledge about the combination of data management and CBMs, of which not many empirical-based theories have been written yet. Theory and data analysis together should be able to answer the research question.

3.4 Data collection

To collect data, this thesis has mainly focused on interviews. Interviews were used to gather information about organizations. Through interviews, insight was gained on how organizations make decisions in the usage of data management that help an organization develop and realize CBMs. The interviews were open and semi-structured, which means that the respondents could

formulate their own answers on questions formulated beforehand (Bleijenbergh, 2015). This has as a major advantage that the questions asked within several organizations are roughly the same, making it possible to generalize the data to some extent and will improve reliability (Bleijenbergh, 2015). The interviews were not entirely the same, because some information that was discovered during the interview led to new questions being asked. However, overarching questions have been asked to all interviewees.

During the interviews, memos have been noted by the researcher. These memos contained certain concepts or statements that stood out during the interview. These memos have been transcribed and have been added to the transcription of the interviews.

3.5 Data analysis procedure

First of all, all the interviews have all been recorded. All the interviews have been transcribed. This was needed in order to code all the interview data. During the whole process of data collection, memos have been taken of things that stood out. Since the human memory is quite restricted, it is impossible to remember everything that happens during the interviews. Therefore, memos have been be helpful in remembering everything that happened during the process of data collection.

After transcribing the interviews, they have been coded (Appendix 1). Coding means labelling fragments of words with certain concepts and to define these labels (Bleijenbergh, 2015, p. 101). This was done to help link the perceived material to theoretical concepts. It has also helped to cut big pieces of text into smaller pieces, making it easier to understand them. Collected data has been be coded without any theoretical expectations. Since there has not been developed a lot of theory about how organizations make use of digitalization in developing CBMs, there was no coding scheme available beforehand. Coding has been done manually (Appendix 1). After labelling fragments of words, labels have been coded axially. This means that overarching categories of labels have be formed, to reduce the total amount of different labels. Finally, the overarching categories have been compared to each other to try and find patterns within all the data. Coding has been done based on the main research question and the three sub questions. Some codes were derived from the theoretical based, but not all of them. After this, the data was interpreted.

After the data was coded, it was interpreted. By interpreting the data, there was tried to find certain relations between certain codes. The labels of the data have been compared with the labels of data collected in several other organizations. There has been searched for concepts

and labels that are present within different interviews in different organizations, to find the common labels present in more than one organization. Some of the labels were covered by theory, others were not.

3.6 Quality of the research

In order to enhance reliability and validity of this research project, the selection criteria of the organizations were determined beforehand. Due to the current COVID-19 disease it was difficult to find a sufficient amount of organizations to be interviewed, as the organizations contacted mainly said to be "busy tackling other matters". Further elaboration on this is in the limitations paragraph in chapter 5. Nevertheless, it was clear what organizations needed to be interviewed.

After the organizations were selected, the interview questions were carefully formulated. As most interviews lasted for approximately half an hour, it was necessary to take the interviews as efficient as possible. The time of the interviews was tried to be as uniform as possible, so no interviewee got more attention than others.

The questions were determined beforehand, so that it was clear what had to become clear from the interviews. Besides this, having the interview questions prepared made it possible to ask all the interviewees roughly the same questions.

When possible, some triangulation was done with secondary information about the organization. All organizations were asked if they were willing to provide documents, but not all of them did. Some organizations had some documents about their CBMs on their website, making it possible to validate some of the answers given.

Because the sample size is relatively small, there are limitations the reliability of the research. Reliability means that the findings are not distorted by coincidental deviations (Bleijenbergh, 2015, p. 120). This is difficult to rule out, since the sample size is rather small. However, what can be done is the maximization of controllability of the data collection. In the appendices, the codes and a summary of the interviews conducted will be provided. This will provide transparency in the way the data is collected, which will improve the controllability and reliability.

4. Results and analyses

4.1 Introduction

The theoretical framework and the conceptual model as described in the previous chapters will serve as the base of the results of this research. The theory, combined with the data gathered in the interviews will make it possible to answer the research question: *How do organisations develop strategies to make successful use of data management in order to develop and realize business models for the Circular Economy.*

In the previous chapter, the organizations and the interviewees have been described. This chapter will present the data and analyses of this data.

4.2 Data presentation

As mentioned beforehand, this research is qualitatively oriented. The largest part of the data comes from semi-structured interviews conducted with employees of the organizations. Some supporting data came from memos of the researcher and from documents provided by the organization or that have been found on websites of the organizations. These documents include policy documents from organizations on e.g. their circular strategy. All the interviews have transcribed and coded, so that a good overview of the results was possible. The extent to which CE is implemented in the organizations and how data management is used to do so will be shown and compared to other organizations.

4.3 Current situation, problems and challenges

The first sub-question of the overall research question was: '*What is the current situation and what are the problems organizations face in making use of data management for developing business models based on circular strategies.'* This question is twofold: what is the current situation and what are the problems organizations face. Therefore, these two parts of the sub-question will be answered separately. First, the organizations will be described and compared.

Organization one

Organization one provides hatchery solutions for businesses. The organization gathers enormous amounts of data about the processes in the organization. This data is analysed and used to improve certain processes. The organization has several plans for CBMs and will make use of data management in these business models to improve processes. However, concretely

there are no CBMs within the organization yet. When implemented, data will mainly be used to improve efficiency and reduce costs.

Organization two

The second organization is a manufacturer of kitchen and consumer electronics. This organization has several CBMs functioning where data management is of serious influence to this business model. The organization creates 'smart products': household appliances equipped with all kinds of sensors to measure usage data. The data will be used to improve product design and perform predicted maintenance, which will improve the CBM as a whole.

Organization three

Organization three is a mattress company. It has a full running circular business model, backed by a data management strategy. The organization sells mattresses with a take-back system, where all the materials will be used to produce new products. All matrasses have a scannable tag with all the information about the mattress in it. Beside this, a customer relations management system is running to store all the consumer data. This makes it possible to take back and recycle their products.

Organization four

Organization four is basically a 'water recycling company'. It provides systems to clients to reuse waste water. All machines that do this are provided with sensors that constantly monitor all the processes. The data gathered is used to improve product design, improve process efficiency and reduce costs.

Organization five

Organization five is a contraction company. It is beginning to implement CBMs and recognizes the potential of both circularity and digitalization strategies. However, it still struggles making a full transition. Right now, the organization is preparing for the transition by for example standardizing certain products. When this is done, several digitalization measures like smart sensoring and gathering usage data will be taken, but right now this is not happening yet. This organization is still in the planning phase for both CE and data management strategies.

Organization six

Organization six recycles plastic bottles. Their whole business is circular, as it reuses and recycles bottles on the same economic level. Contrary to some other companies, this organization has not got any digital strategy. Their main focus is on influencing the supply chain. They do gather data about processes in their organization, but this minimally affects their business.

Comparison of organizations

Below can be found a diagram where all six organizations researched can be found. The vertical axis shows the degree of development of CBMs, the horizontal axis shows the extent to which data management is used within organizations. There is no specific quantification on both axis because the organizations are compared to each other. The intersection point of the axis marks the point of actual implementation of both strategies. Circular strategies below the intersection point have not been concretely implemented yet. The same counts for data management strategies that are on the left side of the intersection point.

All organizations interviewed show similarities and differences, both in their (present or intended) CBMs and the way data management contributes to these strategies. It cannot be said that the extent to which CBMs are implemented is tightly linked to the degree of digital strategies within the organizations interviewed. As can be seen in the diagram below, there are many differences among the organizations. Four of the six organizations have a running CBM. Two of the six organizations are planning the transition but have not yet implemented their CBM.

Of the organizations interviewed, four of the six are actively making use of data management to strengthen their business models. As can be seen, this does not necessarily need to contribute to a *circular* business model, as for example organization one has a sophisticated data management strategy, while their CBMs are still in the design phase.

Organization five stands out, because they tend to have implemented no data management strategy, nor a CBM. The interviewee mentioned that both strategies are actively discussed within the organization, but have not led to concrete strategy implementation

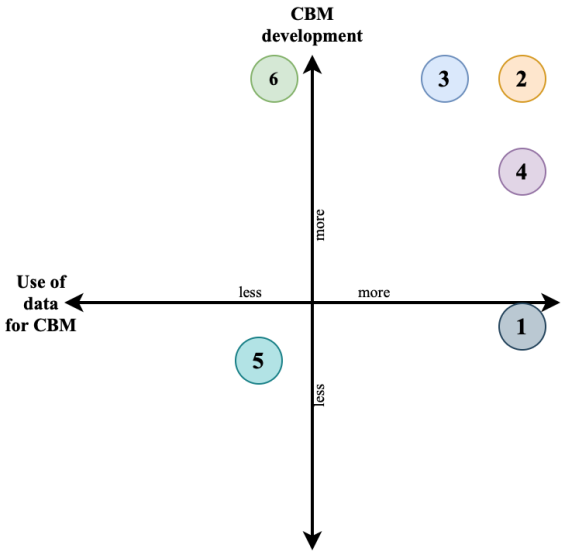

Figure 4.1: comparison of organizations on their CE and data management strategies.

Current situation

The first thing that stood out during the interviews with the organizations is the fact that all of the interviewees recognized the importance of the transition to CE. Different reasons for this were given, but most of them were in line with what has been stated in the theoretical background. As one organization stated: "*We are a family business, we pay much attention to sustainability. We are in the middle of the society, so we value our role. We pay much attention to the materials we use and the effect they have on the world."* On the other hand, all the organizations in this research are well aware of the fact that the main goal of the organization is to make profit. When sustainability is mentioned as a reason, all organizations immediately mention the need to stay profitable. Organizations mention this as a major issue. Due to low prices of raw materials, it is too expensive to produce in a circular way. Because of this, organizations face challenges in how to be competitive with companies that do not produce in a circular way. *"At this moment the price of raw oil is way too low. Virgin plastic is cheaper than recycled plastic and that is a major problem. This is because the actual costs of oil are not calculated within the price, like climate damage and other things."*

The reasons measured above are the two major elements that all organizations have in common: they are all aware of the fact that CE has great potential for a sustainable future. However, all organizations mention that CBMs first need to be cost efficient. If not, no organization will consider changing their business models.

Business model state of things, requirements

As Jonker et al. (2017) already mentioned: the transition from linear to CE requires three elements: the re-evaluation of the role and place of raw materials, the conversion of products into services and the improved utilization of functionality. The three elements are embodied in the pillars provided by the ReSOLVE model of the Ellen MacArthur Foundation (2015). Those six pillars are used to assess to what extent organizations make use of CBMs. This model also makes a direct combination with industry 4.0, and can therefore be well used in this research. The more pillars of the ReSOLVE model are fulfilled, the more sophisticated the CBM of the organization will be, and the more opportunities there will be for the use of IT and data management regarding these CBMs.

Organization / ReSOLVE	1	2	3	4	5	6
Regenerate	X	X	X	X	X	X
Share	X	X	-	X	X	-
Optimize	X	X	X	X	X	X
Loop	-	X	X	X	-	X
Virtualize	-	X	X	-	X	-
Exchange	X	X	X	X	X	X

Table 4.1: Fulfillment of ReSOLVE model by organizations

In the table above is shown what elements of the ReSOLVE model are fulfilled by which organizations. On the positive side can be mentioned that all organizations researched are making use of the Regenerate, Optimize and Exchange pillars. Half of the ReSOLVE model is fulfilled by all organizations interviewed. However, on the other side, sharing and 'loop' as an element of a business model is used by four of the six organizations, virtualizing parts of the organization is done by half of the companies.

Regenerate

All organizations strive to 'regenerate'. This is done by for example managing waste, switching to renewable energy or bio-based products. Most organizations did not specifically use data management in this aspect. However, it does contribute to more circularity. Two examples:

"*We use no more fossil energy. We produce green energy for the network." "Our strategy is to look at waste flows to see if we can retain value. For example biogas or other resources." "We try to use more bio-based products. So instead of concrete, we use wooden products."*

How do organizations make use of digital technologies in regenerating their resources and energy? Both IoT and big data management are used for this pillar of the model. Organizations try to equip their products with all sort of sensors which generate data about the state of products and the way they are used by their owners. This creates a 'connected product', which provides the organization with a large amount of information about the product. This information about the products is then used to improve the product, so that it could be used in a more efficient manner. As one organization put it: "*We do not know how our product is used. If you can measure this, your product design will become more efficient. Certain compounds have to become stronger, while others can be left out."* Not all organizations use data management for this pillar.

Share

Sharing does not only mean literally sharing assets or products. It also means for example the use of second-hand products, or prolonging the lifespan of a product through maintenance (Ellen MacArthur Foundation, 2015). "*The acceptance of a used product by an end user is crucial. Otherwise, we will refurbish products, but it makes no sense. This requires a culture shift from the consumer".* Besides the actual product service systems, prolonging a products' lifespan can be done with help of IoT and Big Data. Generating large amounts of usage data will create the possibility to perform predictive maintenance, which will increase the lifespan of a product. *"If you know in advance that a certain part needs to be replaced, you will prevent other parts to become damaged from this one part breaking apart, which will improve the product."* Gathering usage data for the 'share' pillar is done by two of the six organizations interviewed. Organization one is preparing a CBM by gathering data from customers. By doing this, the organization can gain insights in how it can implement their systems more efficiently: "*We are now working on data exchange where we analyze data of customers. We do this as a service, but the underlying idea is that we understand how the hatchery works and that we can run it for the client by ourselves in the future."*

Optimize

Optimize is the element of the ReSOLVE model that was used by all the organizations. All organizations claimed to make use of data management to optimize their business. Differences were there among organizations, but they all stressed the need to optimize their processes. Data analysis made it possible to do this. The data was gathered in different ways. IoT was one possibility, but data was also delivered by partners in the supply chain. *"You can imagine that our process is very depending on the quality of the goods we get from our suppliers. The quality has to be as high as possible, we are constantly working on improving quality. This is done with data from our suppliers."* "*We make lots of use of Big Data for optimizing our processes. A hatchery is a 0/1 situation. If the egg hatches you will have 10% waste, if it does not you will have 90%. That is why it is crucial to make the processes as efficient as possible."* Optimizing business processes will reduce waste and resource use, which will enhance more circularity.

Loop

By 'loop' is meant remanufacturing and recycling, but also minimalizing the 'resources' that are wasted. Almost all organizations do this, however the extent to what they do it differs. One of the organizations works with a take-back-system, where all used products come back to make new products. Others work with a lease-system, where products will be refurbished once they come back. One thing that stood out was the material passport that was mentioned by several

organizations. The material passport was used by organizations to be able to know exactly what the composition of products was. All the data that is gathered by these passports is stored in a cloud, so that everything is known about the composition of products that come back. "*The mattress is equipped with a scannable tag, making it able to see what the components of the product are, at any time. Even after 10 years. When they come back to us, it will be much easier to separate the components and reuse them."* For organization four and six, which are both recycling companies, 'loop' is of course a crucial aspect of their business model. Both organizations make use of data analysis to improve their recycling processes.

Virtualize

Virtualize stands for dematerializing certain aspects of an organization. Even though much is dematerialized through organizations, production companies have difficulties in doing so, simply because a physical product cannot be virtualized. However, of course, organizations work with lots of digital initiatives that make it possible to reduce material flows. However, the interviewees linked this more to regular entrepreneurship than to CE specifically.

Exchange

Exchange stands for replacement of old-fashioned initiatives with new ones: innovation. Of course, all organizations innovate. Circular economy is eminently a form of innovation. Therefore, all organizations that are working on circular initiatives will fill in the last pillar of the ReSOLVE model. More specific to digitalization, additive manufacturing (or 3D-printing) is a specific example of a digital technology regarding CE. Unfortunately, no interviewee made use of 3D-printing as a part of their business model.

Problems

What kind of problems do organizations face in integrating IT and Data management in their CBMs? Three barriers derived from the literature have been confirmed during the interviews. One specific barrier has not been found in literature, but is added here as it stood out.

Investment costs

Many organizations mention high costs and the uncertainty for data management to add value as a barrier to implement a data management strategy. Organizations are hesitant to invest in data management strategies. *"The most important factor is economy. Eventually, these investment decisions are made because they are economically profitable. This counts both for CE and for data management strategies."* Another organization mentions the same, claiming that the costs of the investment are an important factor to invest or not.

Technological barriers

Technological barriers are for example the need for specific knowledge, privacy issues and infrastructure. The first two have been mentioned as a problem, while the last has not. *"Knowledge is a main issue. Strategic choices have to be made. Do you build the knowledge yourself or internal? […] Eventually you will have to hire data scientists who know how to handle all the data. This can help improving product design."* Privacy issues can also be an inhibitor of a data strategy for CE. *"Sometimes legislation is a problem. You may not use certain elements in recycling because it's prohibited. And for data there is the privacy aspect. This can block such initiatives."*

Cultural barriers

Cultural barriers basically mean that the culture of an organization should be data driven. This Some interviews show that data driven culture is lacking. Mainly organization five appears to lack this data driven culture. "*The transition mainly stagnates on focus. It has not enough priority in the organization."* Or *"We could equip products with smart sensoring, but we consider it not needed at the moment."*. This could be one of the reasons that organization 5 is running behind in the transition of both digitalization and CE.

Uncertainty

The final barrier to data management strategies for the CE mentioned by organizations is the uncertainty that organizations face. This barrier was not derived from literature but might be plausible. Transitioning to a CBM requires investments of which it is not certain whether it will pay off. Organizations that are willing to implement a digital strategy into their circular strategy mainly mention that they are working on a digital strategy, but that data management has not got priority yet, because it is first needed to fulfill the circular strategy. Interviewees recognize the need for such a defined strategy, but it is not their first priority. When CBMs are fully implemented, organizations can start improving this CBMs by means of data management.

4.4 Adoption factors

The second sub-question aims to discover which factors determine the adoption of data management for CBMs. The question is formulated as follows: *Which factors determine the adoption of data management for developing business models based on circular strategies?* During the interviews, several adoption factors were mentioned, which will be discussed in the following paragraphs. Most adoption factors can be connected to the theoretical base, but not all of them. They are closely linked to the earlier mentioned problems organizations face. The

first two adoption factors are categorized as 'Innovation characteristics', meaning that if a data management strategy has the possibility to improve certain aspects of an organization, it will easier be adopted.

Optimization potential

The adoption factor that was most mentioned during the interviews was 'optimization potential'. Optimization potential means the extent to which (a) data management (strategy) has the possibility to optimize CBMs. All six organizations mention the necessity for data management to contribute to their CBM. "*We make use of data to improve processes, change them and give feedback to these processes. To do this, we generate lots of data. This improvement is necessary to make data management useful."* This shows the need for data management to optimize processes. But also to improve product design: *"Data from smart products is incredibly interesting. We do not know how an oven is used. If you can measure that from the product, your product development can improve greatly."* Data management can help improve processes: "*We make use of data to optimize the whole supply chain. The data makes the supply chain more insightful."* "*Data will give insight in use and the condition of products. This helps improving efficiency."*

Cost Efficiency

The second adoption factor that organizations mention is cost efficiency. Cost efficiency is a rather general adoption factor for every entrepreneur, but nevertheless a very true one. The organizations interviewed primary exist for profit. If they innovate, the first incentive is that it should be profitable. "*Circularity is a means of realizing qualitative, affordable real estate with fixed value. The most important incentive is that it will pay off. We are no charity organization. We want to create value and earn profit with that. The same counts for the data strategy. If it supports the circular model, it has to add value."* This counts the same for data management strategies and was also given as an important factor in the literature: it should provide improvements to the organization. "*It has to be profitable. We're still determining how we will use which system and with which partners we will do so. How will it financially be covered?"* "*We are now working on embedded software so that a machine can adapt itself through a cloud. This saves enormous cabling costs, making it possible to make another step."*

A strong and working circular business model

One CE specific adoption factor for data management for CE was the CE itself. What stood out during the interviews is that all organizations are working on CBMs, but that these business models always function next to other business models. "*Since a short period, we have started*

making mattresses that come back to us after use and will be fully recycled. We do this besides the production of 'standard' mattresses." Organizations simply do not know yet whether their business models are profitable or not, mostly because of the uncertainty of how products can be recycled. Products will be used by end-users for a long period of time, making it difficult to assess upfront what the value of this product will be after it comes back. The fact that this gives a lot of uncertainty is one major reason for organizations to hold back on digital strategies for these CBMs. "*We are in the development of our data strategy. The challenge is that we do not know what we want to measure and how to do this. So, we need some experience."* Organizations would like to gain more experience about their circular businesses, before the complete data strategy can be enrolled. "*Important for the data strategy is that the circular model functions. We do this with help of data but that is optimization. First, the circular model should be up and running, after this we can really look how to improve products and services by data."*

Company Culture

After the CBM has been up and running, organizations will try and implement an efficient data management strategy. An important adoption factor for this is company culture. By company culture is meant that within the organization there should be people that are convinced of the success of a combination of data management and CE. If this is not the case, there will be no CBM and no digital strategy for this business model. "*You need people within your company that are convinced of this and want to go for it. If you do not have any pacemakers within your organization, it will never start up."* If there are people within an organization that have an innovative mindset and are motivated to make such models work, there is a way larger change that it will actually happen. Organizations need to have people within the company that have a progressive mindset.

Long Term Vision

The final adoption factor for digital strategies for CBMs is a long-term vision. This long-term vision is needed, because of the earlier mentioned uncertainty that comes with circular entrepreneurship. *"CE requires a long-term vision. You pre-invest in materials which last for years. This is very different than the quick revenues of the linear economy. If you want quick profit, you better innovate on other things."* Because of this uncertainty for CBMs, this applies the same to the digital strategy regarding CBMs. Organizations that are investing in CBMs do this with a long-term vision which will deliver profit in the far future. Decisions are made with a view on the long term: *"The process costs a lot of time, and a lot of knowledge is required.*

Maybe it is not necessary to invent the wheel ourselves. However, if you hire third parties, you will not build up the knowledge yourself. This could be a disadvantage on the long term."

4.5 Implementation conditions

The third sub-question aims to find the implementation conditions to make the integration of data management into businesses a success. The last sub-question is formulated as follows: *What are the conditions companies are implementing in order to successfully integrate data management into business models for a Circular Economy?*

The three implementation conditions that were mostly mentioned during the interviews are the following: the right data has to be gathered, the infrastructure of the digital environment should be well-designed and the employees working with the data should be skilled. Not all implementation conditions described in the theory have been found. The conditions found will be discussed below. The implementation conditions described in theory are mostly looking at organizational factors that are necessary to implement data management strategies for the CE. The last implementation condition is not considered 'organizational', but stood out during the interviews.

Skilled personnel

The first implementation condition that stood out during the interviews was skills. Organizations recognize the need to hire people who are specialized in data management, so called data scientists. These people have the specific knowledge to know exactly how to manage large amounts of data. Even though most organizations have not yet decided on the need of this type of personnel, organizations recognize the need to invest in data scientists once the need is there. Because the data management strategies of organizations interviewed are still in their infancy, this need is currently not there. "*There has to become a need for a data scientist. In the future there will be a massive pool of data, of which someone needs to make an understandable text. A Data Scientist can make this translation in the future."*

Strategic alignment: gathering the right data

The second success factor is that organizations know which data to gather. This is tightly connected to the other conditions. In current times, it is possible to gather huge amounts of data, without knowing exactly what to do with it. If organizations do not have strict plans on what data to gather, they will never know what to do with it. "*You have to ask yourself what you want to measure. You can equip the appliance with all sorts of sensors, but if you cannot do anything*

with the data it is useless. You have to think in advance, at your product design, which data you want to gather."

During the interviews became clear that there are two sorts of data that can be of great potential for CBMs: on the one hand usage data, on the other hand data about the customers.

Creating products 'connected' means that products are equipped with sensors that will gather all sorts of data about the way a product is used, what the status of parts is and whether maintenance is required. This data will not only allow organizations to perform predicted maintenance, but will also raise massive potential to improve products based on the data of users. "*When a certain part of a machine is used intensively by the end user, this can be a reason to strengthen the product, so that it will last longer."* Eventually, this usage data can enhance products' lifespan, which will contribute to more circularity.

The other category of data is customer data. Customer data is needed to 'stay in touch' with customers. While normally customer data is used for marketing purposes, it is now needed to retain contact with customers to make sure the products are still in good state, but also to make it possible to take back products once they are worn out. "*The most important is to take back the product. Clients give us their contact information with their purchase, so that we can remember them during the use period that the product needs to be returned."* If products will be returned after use, organizations will have the possibility to refurbish the product, or take out components that are still useable.

Infrastructure

The final condition to implement IT and data management in CBMs is a good infrastructure for the data. The amount of data gathered by sensors is so enormous that it will require a good data infrastructure to store all the data. Organizations can either choose to buy this infrastructure from external companies or design it themselves. Most organizations interviewed prefer to buy these IT-solutions, because they do not consider it necessary to reinvent the wheel. Data storage systems are widely available on the market, so buying it will be more efficient than designing it. Besides this, most organizations interviewed already have a certain digital infrastructure available, wherein the data can be stored/analysed: "*Within our current e-commerce surrounding, we have the possibility to implement a module which can support usage focused business models. We simply install an extra plugin."*

After systems have been bought, it is necessary for organizations to have clear instructions on how to generate, store and analyse the data. Most organizations do this by creating policy documents that describe certain processes and steps in the whole data system. Organizations

literally make rules of play, so that the way data is generated, stored and analysed is always uniform: *"The processes will be noted down in process descriptions. We have templates for this. Besides this we also note down the infrastructure and the architecture of what we need from the systems. We have a so-called system architect for this. He will create a sort of spider's web where all the systems and the relations to each other are described. This creates an overview of the complete digital system we have."* These types of structure make the data manageable.

5. Conclusion and discussion

The final chapter will give a conclusion to this research project. It will first answer the three sub-questions, which will eventually lead to an answer to the main research question: How do organisations develop strategies to make successful use of data management in order to develop and realize business models for the Circular Economy?

After this, a paragraph will concentrate on discussing this research project. It will present limitations to this research, the contribution to theory and practice and will conclude with further research suggestions.

5.1 Conclusion

Sub-question one: current situation and problems

The first sub-question focused on how the current situation of organizations was and what problems organizations' experience in integrating data management into their CBMs. First of all, it must be concluded that not all organizations had actually started a fully running CBM. Four out of six organizations had implemented a CBM, while two of them had not fully implemented their CBM. However, these two organizations did fulfill a lot of the pillars of the ReSOLVE model, so in fact they were more circular than they might have thought. Organizations mentioned that it was difficult to decide what the right data management strategy would be. A running CBM is therefore one factor that influences the possibility of adopting a digital strategy for the CE (see RQ2).

Organizations that had a running CBM struggled with lots of uncertainty. Because most organizations that were interviewed sold products to last for longer periods of time, it was yet unknown how products would come back and what 'the next step' was going to be. This resulted in uncertainty about which data to gather and what could actually be done with this data. Most organizations recognize the need of data management for improving efficiency and processes in their CBMs. However, they face several barriers to implement these strategies: high upfront investment costs, technological requirements such as infrastructure and skilled personnel and the lack of 'data driven culture' are mentioned by organizations. All these barriers need to be overcome to be able to implement data management strategies for the CE.

The ReSOLVE model was used to see to what extent organizations had actually developed their CBMs and how data management contributed to each of the pillars of the model. Some organizations were very far in their development, while a few others were still at the design

phase of their business models. The degree of data management used in these business models varied, there was no clear link between the extent to which a CBM was developed and the degree of data that was used. This might be because organizations do not clearly see the chances that digital technologies offer for their circular activities.

Sub-question two: adoption factors of data management for the CE

The second research question tried to distinguish the adoption of IT and data management for developing CBMs. In the literature, no studies were found about specific adoption factors of data management for the CE. Therefore, adoption factors of general (big) data management strategies were used. They matched quite well with the ones discovered during the interviews. In total, five adoption factors were found: optimization potential, a strong and working business model, company culture, a long-term vision and cost efficiency. The five adoption factors are closely tied together. From all adoption factors can be concluded that the more they are available to the organization or the better they are fulfilled, the stronger they will contribute to the adoption of data management strategies for the organization. The use of data management itself has to contribute to two factors. A data management strategy should lead to more efficiency (optimization potential) and reduce costs (cost efficiency). If this is the case, organizations are open to implementing digital strategies. Besides this, the organization has to fulfill the other three as much as possible. With a strong and working CBM it will be easier to develop a strategy that supports and improves these business models. Besides this, organizations will have to look on the long term, and the culture within the company should support (digital) innovation for both the CBM and the data strategy supporting it.

Sub-question three: implementation conditions

The last sub-question aimed to find out what the conditions are that need to be implemented by organizations in order to successfully integrate IT and data management into their CBMs. Three conditions were found: right strategic alignment, the right infrastructure and sufficiently skilled personnel. If these conditions are met, it will become easier to implement data management strategies into CBMs and make them successful.

First of all, it is very important that organizations know which data to gather. This is closely linked to the problem stated in RQ1 that organizations face uncertainty about the future. If organizations do not know which data needs to be collected, it will be useless to start collecting data at all. Therefore, data strategies should contain detailed information about the content of the data strategy. However, there is a possibility for organizations to learn by doing. Organizations might first struggle with the collection of their data, but after time will become

more skilled in what data to collect to improve their CBMs. Therefore, the condition of 'the right data' is one to be created in order for data management to be beneficial to CE. Usage data and customer data are mentioned in the interviews as types of data to be collected that improve CBMs.

After organizations know which data to collect, the right infrastructure should be created. The way data is stored and managed by the organizations is important to be able to analyze it. CRM-systems or e-commerce surroundings are types of infrastructural appliances to manage data. If organizations find ways to structure the data in a well manner, it will be easier and better to analyze. These infrastructures have to be clear for organizational members, so everyone knows how to gain full benefit. This will contribute to the improvement of the CBM.

Finally, the people in the organization are crucial. If done well, huge amounts of data can be gathered about products. This creates the need for skilled personnel to analyze this data. Like one organization mentioned very typical: if you have a massive pool of data but do not know what to do with it, it is completely useless.

Conclusion

What is the overall conclusion to the main research question? First of all, organizations need to make sure their CBM is up and running and other barriers will be overcome. If the barriers are taken away, the possibility for organizations to make use of data management to improve their business models is created. This can be done by analyzing usage data (IoT/Big Data Analysis) or customer data and could improve efficiency or product design. Besides this, costs could be reduced. The improvement of efficiency and design will lead to better and longer lasting products, creating more circularity. Organizations should do this by starting to analyze which data is needed to improve their business models. Besides this, organizations should facilitate an environment which is suitable for innovations, so that the data gathered is managed well. By environment is meant both the right infrastructure for the data itself, as the right environment for people within the organization.

5.2 Discussion

Limitations

This paragraph will discuss the limitations of this research project. Both validity and reliability will be discussed, based on the sample size and choice.

Sample size

Because this thesis has had a qualitatively focused research approach, the sample size was small. The amount of organizations researched was six. Therefore, there are some limitations the validity of the project. Smaller sample sizes make it difficult to generalize certain observations to a larger population. However, this study did not necessarily aim to generalize findings. It has tried to find certain patterns in organizations.

Because the sample size is relatively small, there are limitations to the reliability of the research. Reliability means that the findings are not distorted by coincidental deviations (Bleijenbergh, 2015, p. 120). This is difficult to rule out, since the sample size is rather small. However, what can be done is the maximization of controllability of the data collection. In the appendices, summaries of the interviews and the codes given will be provided. This will provide transparency in the way the data is collected, which will improve the controllability and reliability.

Sample choice

Secondly, the organizations that were available for interviews were not very specifically selected. Because it was very difficult to find organizations willing to cooperate, it has not been possible to make any further demands to the organizations interviewed than that they were working on CBMs and making use of data management in a certain way. This has as a consequence that the sectors organizations operated differ a lot. If this research would have been done with organizations operating in one specific sector, the results would have been more valid and reliable. Unfortunately, this has not been possible. The fact that organizations were not very strictly selected influences both validity and reliability.

However, this thesis has tried to contribute to the broader field of research in finding common factors that might be applicable in a wider field of organizations. So, it has tried to find elements that could be used for more organizations in their transition to CE and give recommendations about these possible measures. Nevertheless, further research is needed to generalize findings to a larger group.

The final remark to make is that the research is quite general. Because of the small amount of organizations and the difference among them it has been difficult to give very specific recommendations to organizations on what to do when trying to implement data management into their CBMs. The results are not very in depth, but might be a good starting point for organizations to investigate how to make better/more use of digital technologies in their CBMs.

Contribution to theory

This study contributes to theory because it is an empirical study. A lot has been written about CE and data management, but the combination is still rather unwritten about and the research that has been conducted about the factors that determine the adoption and the success of data management for the CE was mostly based on experts' opinions and literature studies. Theory gives large amounts of purposes for organizations to improve their strategies, however this research shows that most organizations try to keep it 'basic'. This means just making use of data management to improve processes and efficiency. This has not been shown in theory yet. The fact that organizations mainly make use of data management to support their businesses might also show that organizations in practice have not yet unlocked full potential of industry 4.0. More empirical research about the actual use of data management for CE needs to be done, but this thesis makes a starting point for more research.

Contribution to practice

This thesis contributes mainly to practice. It gives organizations some sort of guideline on where to start with their CBMs and how to make use of data management in these models. It shows that organizations need to focus on their CBMs before implementing an actual data management strategy for these CBMs. The order of the two is important, because the data management strategy is supportive for the CBM. It shows which barriers organizations will need to overcome to be able to implement a data management strategy for their CBM. It shows that organizations should create an environment that will be beneficial for data management to be able to thrive in CBMs. This means that the organizational culture should be data driven, infrastructure should be functioning and the skills of the personnel should be sufficient. This has to be made clear to all the members of the organization, so that the fit between what needs to be done and what is actually done is as good as possible. Managers can make use of the adoption factors and the implementation conditions to create this environment. IoT and Big Data Analysis can be used to improve their CBMs, but can also be used to improve other processes that back the CBM. This research project could inspire managers to start thinking about data management strategies for their CBMs, eventually contributing to a more circular world.

Further research suggestions

Like already mentioned, this research project is a qualitatively oriented research. In order to present findings that are generalizable to a larger group of organizations, it could be useful to

perform quantitative research about this subject. With a larger sample, assumptions about certain adoption factors or implementation conditions could be tested. Besides this, it could be interesting to perform more research to organizations in a specific sector, so that more recommendations could be done that apply to other organizations in the same sector. Due to the small sample size of this research, that has not been possible here.

One major aspect of the CE has not got a lot of attention in this research project is cooperation in the supply chain. Literature considers supply chain cooperation as one important aspect of the CE. Because individual companies have been researched in this thesis, little attention has been paid to the cooperation of firms in the supply chain. Future research could investigate the possibilities of data management strategies to improve CE in whole supply chains.

Finally, a future research suggestion is to research the actual strategy formation for circular economies. How do organizations get into a transition? What are motives for organizations to consider a transition to CE? This suggestion does one step back. Where this research has looked at the development of data management strategies for the CE, it could also be useful to look at the strategy formation of circular strategies themselves. This has not been done in this thesis, but might be interesting to do so in the future.

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7. Appendices

Appendix 1: interview codes

Interviewee	Text	Code
4PET	Dat is materiaal wat in de PMD zak hoort. Dat wordt bij afvalverwerkers gescheiden en per kunststofsoort gebaald. Die balen nemen wij in en verwerken we tot nieuwe bakjes. Dat doen we in drie fabrieken. De schoonmaakwerkzaamheden en granuleren gebeurt in duiven. De flakes worden vervolgens door de foliemakers weer verwerkt tot folie. Dat verkopen we aan bakjesproducenten en die maken er vervolgens weer flessen/bakjes van. Dat is het proces.	Regenerate / Loop
4PET	Er zijn heel veel intiatieven die verschillende partijen in de supply chain bundelen. Die brengen het aanbod en de vraag bij elkaar. Dat gebeurt op alle niveaus. Wij doen aan al die programma's mee. OP internationaal niveau proberen wij de regelgeving te beinvloeden om producten geschikt te maken voor recycling door bijvoorbeeld het design.	Exchange
Auping	Wij gaan nu matrassen (sinds gister te zien in reclames) maken die na gebruik bij ons terugkomen en waarvan we alle materialen hergebruiken tot nieuwe matrassen. Dus we willen niet recyclen, maar met een volledig gesloten loop werken waarbij materialen zonder downcycling opnieuw worden toegepast. Dus we willen niet naar een lager economisch niveau. Dus niet van een matras naar een asbak of bermpaaltje, maar echt van matras naar matras.	Loop
Nijhuis	wij zorgen dat water wordt hergebruikt. Dat is ons eindproduct. Water is schaars. Dat betekent dat voldoende water een absolute voorwaarde is voor productie. Daarom is er behoefte om water te hergebruiken en dus circulair terug te voeren om zo die loop dicht te maken. Wij kunnen van afvalwater weer drinkwater maken. Er is simpelweg onvoldoende grondwater beschikbaar voor productie, en het grondwater wat er is begint steeds zouter te worden. Maar niet alleen water is schaars, maar grondstoffen ook. Bijv fosfaat of vetten. Er zijn allerlei systemen om dit terug te winnen uit water. Dat is interessant voor bedrijven om die kringloop te sluiten. Dit is veel makkelijker haalbaar op bedrijfsniveau dan op bijvoorbeeld regionaal/landelijk niveau.	Loop

ATAG	We zijn druk aan het onderzoeken of we producten die terugkomen kunnen refurbishen. Dat doen we in een project: circular kitchen. In samenwerking met de TU Delft, Bribus en een zweedse universiteit. Daarmee ontwikkelen we allerlei businessmodellen en concepten om producten circulaireder te maken en om te kijken wat andere verkoop- en leasemodellen zijn die we kunnen toepassen.	Loop / Exchange
ATAG	Als ik kijk naar refurbishment zijn er meerdere factoren: het nieuw in de markt brengen van bestaande producten. Ten tweede: een product dat terugkomt moet worden schoongemaakt, onderdelen moeten worden uitgewisseld. Als het niet meer te repareeren is doen we aan part harvesting, om bepaalde onderdelen later weer een tweede leven te geven. Dat zijn trajecten waar we mee bezig zijn.	Loop / Regenerate
4PET	Je zult je kunnen indenken dat het proces heel erg afhankelijk is van wat wij aan kwaliteit geleverd krijgen van afvalverwerkers en de supermarkt is afhankelijk van deze kwaliteit of ze er nieuwe verpakkingen van kunnen maken. Dat moet zo goed mogelijk zijn. Hier zijn we veel mee bezig.	Optimize
4PET	Wij proberen de supplychain zo in te richten dat afvalverwerkers de materialen die wij niet gebruiken gratis weer terugnemen. Dat is wettelijk niet geregeld, daarom praten we met partijen als rijkswaterstaat om dat te regelen. Zo moet het product verbeteren, wat leidt tot meer circulariteit en meer winst. Daarmee verbeter je dus alle processen.	Optimize
ATAG	Zo zijn we van voor tot achter bezig die footprint beter te krijgen. Zowel van producten als van onze organisatie. En hoe kunnen we producten zo lang mogelijk in de markt houden en dat op een zo verantwoord mogelijke manier kunnen doen.	Optimize
Pas Reform	We zijn wel veel bezig met afval management. We proberen het procues succesvoller te laten zijn. Ieder ei wat goed uitkomt levert weinig afval op. Een ei dat niet uitkomt levert veel afval op. Dat scheelt dus heel erg. Door de processen te optimaliseren zorgt ervoor dat we veel minder afval produceren. We proberen ook wel met het afval wat we over houden wat te doen. We composteren het afval, of we hydroliseren het. Daarmee kan het als mest worden gebruikt of als component voor diervoeding. Daarmee verlaag je ontzettend je afval en kun je meer waarde toevoegen.	Optimize / Loop

4PET	We hebben een werkgroep gestart met een aantal partijen in de branche om over problemen en oplossingen te spreken met partijen die daar iets over te zeggen hebben. Wij zijn aangesloten bij het overheidsinitiatief van de CE (grondstoffenakkoord). Dat zijn allemaal vehikels om ervoor te zorgen dat we invloed uitoefenen op zowel de afvalverwerkers om de scheiding te verbeteren en aan de andere kant de bedrijven die verantwoordelijk zijn voor het design van de verpakkingen om te zorgen dat ze zo geproduceerd worden dat ze goed recyclebaar zijn. Dus eigenlijk door in de supplychain te proberen het te beinvloeden.	Optimize / Regenerate
ATAG	Bijvoorbeeld woningscorporaties die apparatuur willen gaan we ontzorgen. Dan spreken we een contract af van bijvoorbeeld 15 jaar. Dat is dan niet alleen het product wat zij leasen, maar daar zit dan ook bij dat bij iedere woningmutatie de producten worden gecontroleerd, defecten worden gecontroleerd en omgewisseld wanneer nodig.	Regenerate
Nijhuis	Onze strategie is te kijken wat we met de reststromen zou kunnen doen om bijvoorbeeld biogas te maken of grondstoffen terug te winnen.	Regenerate
Pas Reform	Wij gebruiken in Doetinchem geen energie meer. Wij produceren voor het net. We hebben ons verpakkingsmateriaal zeer verminderd.	Regenerate
Plegt-Vos	We gaan niet meer inzeten op betonnen producten, maar op hout. Meer bio-based	Regenerate
ATAG	Je moet werken met Connected/smart appliances werken. Je koppelt een toestel aan het internet. Dat toestel moet dan de techniek bevatten om gegevens te kunnen verwerken en door te geven. En je moet dan dus een backend systeem hebben waarmee je die data kunt verwerken.	Virtualize
ATAG	We maken gebruik van een materiaalpaspoort waarin alle componenten bekend zijn en alle veranderingen worden geregistreerd, zodat je op ieder moment aan het product kan zien van wat is het precies, wat zit erin en wat kunnen we er nog mee. Dat is best een omvangrijk project	Virtualize
ATAG	Maar aan de andere kant werken we ook met predictive maintenance, dat je een product gaat onderhouden voordat een consument weet dat er iets mis is. Daarmee blijft het toestel beter werken.	Share
Pas Reform	Daarom zijn we nu bezig met die data exchange van klanten waarbij we de data voor de klant analyseren. Dat is nu nog een service voor de klant, maar de achterliggende gedachte is dat wij gaan begrijpen hoe we de broederij in de toekomst voor de klant kunnen gaan runnen. De eerste stappen hierin worden dus gemaakt. Maar dat is wel toekomst.	Share

4PET	de belangen van de verschillende partijen lopen uiteen. Het belang van de afvalverwerker is om zo veel mogelijk kilo's te verwerken. Hier worden ze voor betaald. En wij willen zo hoog mogelijke kwaliteit. Dus daar zit een tegengesteld belang. Dat maakt het lastig om een modus te vinden die voor beide partijen interessant is.	Problems
Plegt-Vos	Transitie loopt vast met name op focus.	Problems (Culture)
Plegt-Vos	Maar om echt te zeggen van wij weten wat er momenteel in gebeurt die wanden, nee. Die behoefte is er nog niet	Problems (Culture)
Nijhuis	soms wetgeving. In sommige gevallen mag je water niet hergebruiken omdat het bij wet is geregeld. Of je moet een certificeringstraject door. En bij data gaat het ook om een deel privacy. Maar veruit de belangrijkste is economie. Uiteindelijk worden dit soort investeringen genomen omdat ze economisch rendabel moeten zijn. Dat gaat zowel om CE als om het digitaliseren daarvan.	Problems (Cost & Privacy)
ATAG	Wat het kost, hoe veel tijd het kost, hoe veel kennis ervoor nodig is. Met name kennis. Er zijn al bedrijven die al helemaal gespecialiseerd zijn in dit concept. Dan is het misschien niet nodig om het zelf allemaal uit te vinden. Dat is een strategische keuze.	Problems (Technological, Cost)
ATAG	Uiteindelijk zal daar dan een data-scientist moeten worden aangenomen die ook weet wat hij met die data zal kunnen. Aan de hand daarvan ga je doorontwikkelen op je toestellen. Alles valt en staat met hoe je je toestel voorziet van sensoren om die data te genereren. Hier moet je vooraf over nadenken, want anders krijg je niet de goede data.	Problems (Skills)
Nijhuis	Maar veruit de belangrijkste is economie. Uiteindelijk worden dit soort investeringen genomen omdat ze economisch rendabel moeten zijn. Dat gaat zowel om CE als om het digitaliseren daarvan. Het gaat puur om geld. Dus als we CE verder willen stimuleren, dat we de schadekanten van grondstoffen economisch een waarde moeten gaan geven. Zoals bijvoorbeeld bij CO2 emissie. Anders ga je het niet redden.	Problems / Cost efficiency
Nijhuis	het is altijd moeilijk om op hetzelfde economische niveau terug te komen. Daar zijn in onze business heel veel verwerkingsstappen mogelijk. En heel vaak is dat toch lastig. Dat zie je heel vaak. Een van de grote belemmeringen van de CE is dat je dat model niet op die manier moet hanteren. Je moet verder kijken. Wij bouwen systemen waarbij we bijvoorbeeld vet uit water kunnen halen. Maar met de huidige olieprijs kan dat absoluut niet uit. Daarom is er subsidie nodig. Zelfs windenergie kan niet uit met de huidige energieprijs.	Problems

Auping	we zijn een familiebedrijf, heel veel aandacht voor duurzaam werken. Onze rol in de maatschappij is heel belangrijk. We zijn veel bezig met duurzaamheid. En we zijn natuurlijk een productiebedrijf dus er is veel aandacht voor de materialen die we verwerken en verbruiken in onze producten en wat dat betekent voor de wereld. Dat proberen we zo zorgvuldig mogelijk te doen.	Company culture
ATAG	We zijn nog in aftastende fase met welk systeem gaan we gebruiken, hoe gaan we dat gebruiken en welke partners gaan we daarbij gebruiken. Want je hebt het niet alleen over partners, qua afhandeling van het PPU stuk, maar ook de registratie van data en het hele betalingsverkeer. Dus hoe ga je het financieel afdekken. Er zijn al hele rekenmodellen gemaakt van wat het moet gaan kosten. Het moet voor ons ook rendabel zijn.	Cost efficiency
Nijhuis	Een tweede stap is grote besturing automatiseren. Grote installaties vergen enorm veel besturing. Wij zijn nu bezig met embedded software zodat die machine zichzelf kan aanpassen en kan bijstellen via de cloud. Daarmee bespaar je enorm op bekabelingskosten en kabels. En op koperdraad. Dus ook zo scheelt het weer in de kosten en daarmee kun je een stap zetten. Hier maken wij volop gebruik van. En de digitale procesoperator wordt heel belangrijk, maar moet wel zelflerend zijn. In principe is dat machine learning.	Cost efficiency
Plegt-Vos	Een hele belangrijke incentive om te beginnen met circulariteit is dat het geld moet opbrengen. We doen het niet alleen omdat we het goed willen doen voor klanten als goed doel. We willen ook meer waarde toevoegen aan producten en aan de grondstoffen die je gebruikt.	Cost efficiency
ATAG	Wat het kost, hoe veel tijd het kost, hoe veel kennis ervoor nodig is. Met name kennis. Er zijn al bedrijven die al helemaal gespecialiseerd zijn in dit concept. Dan is het misschien niet nodig om het zelf allemaal uit te vinden. Dat is een strategische keuze. Hoe ver gaan we dit trekken in de toekomst. Hoe breed willen we dit concept inzetten. Want als je het bij een derde partij legt ga je zelf de kennis niet opbouwen, maar gebruik wel kennis die ze nu al hebben. Maar je bouwt dus zelf geen kennis op. Dat kan op langere termijn een nadeel zijn.	Long term vision
Auping	Het product wordt pas na 10 jaar afgedankt. Dus je neemt echt een tijd afstand van het product, dus je hebt er een tijd lang geen zicht op. Dus het is heel moeilijk in te schatten wat de restwaarde is. Dat is echt van belang bij circulair werken. Daarom is het belangrijk dat je op lange termijn kijkt naar de business. Dat is het belangrijkste.	Long term vision

Auping	Wat we nodig hebben is langetermijnvisie. Het is echt heel anders dan de gangbare snelle winsten van de lineaire economie. En daar moet je gewoon jaren lang in investeren en dan kun je er uiteindelijk voordeel van krijgen. Maar als je het doet voor snelle winsten dan kun je beter op een ander vlak innoveren. Digitalisering die hieraan bijdraagt gaat ook op de lange termijn pas resulaten geven.	Long term vision
4PET	We maken gebruik van data door allerlei processen te verbeteren, aan te passen, te meten en dan weer terug te koppelen. Het plan-do-check-act verbetercirkel. We doen hierbij veel met data-management. We genereren heel veel data om onze processen te analyseren. Het signaleren van knelpunten en door middel van data die te analyseren en weg te nemen.	Optimization potential
4PET	We gebruiken in al die fases van het proces data. Maar dit is vooral om de processen te optimaliseren. Dit gebeurt in de hele keten. De data maakt de ketens inzichtelijk.	Optimization potential
4PET	We verzamelen met name veel data om de processen te optimaliseren.	Optimization potential
ATAG	Vanuit circulariteit willen we kijken naar de sensoriek voor apparaten waarmee je de maintenance kan doen. Niet op basis van de leeftijd componenten vervangen, maar eigenlijk doet op basis van iets gewijzigd gedrag van het product (temperatuur of energieverbruik of andere factoren). En dan proactief onderhoud plegen zodat een consument niet hoeft te wachten tot zijn koelkast kapot gaat, maar een periode ervoor een belletje krijgt van goh wij komen even langs onderhoud plegen en het vooraf oplossen.	Optimization potential
ATAG	Slimme producten waar je veel data uit kan halen, dat is ontzettend interessante informatie m mee te nemen in de ontwikkeling van producten. We weten niet hoe een oven gebruikt wordt. Hoe vaak, welke programma's. Als je dat vanuit het product kan meten, kun je veel gerichter je productontwikkeling doen. Bepaalde onderdelen moeten sterker, terwijl andere onderdelen misschien weggelaten kunnen worden.	Optimization potential
Auping	je krijgt inzicht in gebruik en verbruik. Je kunt daarmee ook naar pay-per-use. CE gaat ook over producten refurbishen zodra het nodig is. Als er amper op een matras gelegen is maar hij is wel 10 jaar oud. Dan kun je hem hergebruiken in plaats van uit elkaar halen. Daarmee krijg je dus veel meer inzicht in het gebruik. Maar ook van belang om te weten welke materialen er in een product zitten. Dat weet je namelijk over 10 jaar niet meer. Dan is het wel fijn dat je een digitale koppeling heb aan je product.	Optimization potential

Nijhuis	Bij hergebruik van water heb je zo veel processtappen nodig dat je het zult moeten digitaliseren. We zijn bezig met een digitale operator die op basis van data processen gaat sturen. Daardoor kun je sneller schakelen, heb je minder mensen nodig en worden je installaties goedkoper.	Optimization potential
Plegt-Vos	digitalisering in de bouw is vooral 3D modellen, waarbij een bouwwerk vooraf wordt gemoduleerd voordat hij gemaakt wordt. Daarmee kun je veel fouten eruithalen en je materiaalefficientie zo goed mogelijk te doen	Optimization potential
Pas Reform	Wij maken gebruik van Big Data. Wij zijn hiermee volop in ontwikkeling. Dit zit in het optimaliseren van de bedrijfsprocessen. Klanten leveren enorme hoeveelheden data bij ons aan. Wij gaan hiernaar kijken, wij analyseren dit om de processen te verbeteren. Wij zijn een systeem aan het opzetten waarmee de klant zijn data kan uploaden waarmee wij de analyses kunnen doen. Daarmee proberen we de processen te verbeteren, zodat afval wordt geminimaliseerd. Dit leidt weer tot meer circulariteit	Optimization potential / Cost efficiency
4PET	Dat komt omdat bij materialen als aardolie nog altijd niet de daadwerkelijke kosten worden meegerekend. Zoals milieu en klimaat en andere belastingen. Dat moet opgelost door wetgeving. Het beste zou zijn om een wetgeving te hebben waarin een verplichting bestaat dat kunststof verpakkingen voor een bepaald percentage uit gerecycled kunststof moeten bestaan. Dan trek je de prijzen recht. Maar dat zijn op dit moment de grootste verstorende factoren. Pas als je die oplost kun je echt verder gaan ontwikkelen.	Strong and working BM
ATAG	Dus we doen aannames: hoe lang zal het product staan, wat voor contracten worden afgesloten? Of je maakt een systeem met een minimale gebruiksduur. Daarom is het belangrijk dat gebruikers de producten zo lang mogelijk gehecht zijn aan het product en hem niet kwijt willen. Dat is wel iets waar je goed over moet nadenken en waar je ideeen voor moet hebben hoe je dat gaat doen. Voor de data is het van belang dat eerst het circulaire model goed staat. Dit doen we natuurlijk met behulp van data maar dat is optimalisatie. Eerst moet het circulaire goed staan, daarna kunnen we echt kijken hoe we de producten en services kunnen verbeteren door data.	Strong and working BM

Auping	Belangrijkste is beginnen bij het ontwerp en de materialen die je gebruikt. Komen tot een modulair ontwerp waarbij de verbindingen weer ontdaan kunnen worden en gebruik maken van materialen die daar geschikt voor zijn. Dus begint echt met ontwerp, dat is heel belangrijk. Vervolgens is het belangrijk dat de consument het product ook retour stuurt. We hebben een takeback systeem opgericht. Hierbij halen we matrasssen terug en zo goed mogelijk verwerken. Dat is een onderdeel naast ontwerp. Verder ontwikkelen we dus ook recyclecapaciteit, om zelf de verwerking van matrassen te doen. Dat is best wel een opgave. Ontwerp is belangrijk, retourstroom is belangrijk en de verwerking nadat het terug is gekomen. Die drie takken moeten we realiseren. Daarna gaan we pas kijken naar de data.	Strong and working BM
4PET	de inkomende goederen moeten van hogere kwaliteit. De kostprijs is te hoog. Van zowel de grondstof als de processen. Er zijn allemaal zaken die de totale kostprijs duur maken. En de verkoopprijs t.o.v. virgin is te laag.	Strong and working BM / Optimization potential
ATAG	deze data generatie is cruciaal, maar het loopt een beetje naast elkaar. Het circulaire loopt naast het uitrollen van connected appliances en versterkt elkaar wel. Door het verzamelen van data kunnen de circulaire businessmodellen veel beter ontwikkeld worden.	The right data / Strong and working business model
Nijhuis	je wilt weten hoe de processen lopen. Of de waterkwaliteit voldoet, of je voldoende produceert. Allemaal sensoren meten dit. Op basis van die data wordt het proces verder geoptimaliseerd.	Right data
ATAG	als ik dat doorvertaal naar data, dan is data cruciaal om dat te kunnen besturen. Begint met producten die gekoppeld zijn aan het net (connected products), de je op afstand kan monitoren.	Right data
ATAG	We verzamelen vooral verbruiksdata. De producten worden allemaal connected. Daarbij moet je gaan afvragen vooraf wat je allemaal wilt meten. Bijvoorbeeld het aantal wascycli van de wasmachine. Maar ook hoeveel wasmiddel de klant gebruikt en hoeveel wasverzachter. Dit soort informatie gaan we gebruiken om te analyseren, om zo de producten te verbeteren zodat ze langer en beter meegaan	Right data / Optimize
ATAG	Lastige is nog steeds hoe je goed/helder kan meten dat iets gewijzigd wordt en wat voor sensoren heb je daarvoor nodig. Je moet het wel tot de basis afpellen. Anderzijds is het ook qua sensoriek moeilijk welke kennis er beschikbaar is en wie ons daarmee kan helpen. Uiteindelijk moet dat vanuit een stuk voorontwikkeling in de volgende generatie opgenomen worden.	Right data / Skilled personnel

ATAG	Uiteindelijk zal daar dan een data-scientist moeten worden aangenomen die ook weet wat hij met die data zal kunnen. Aan de hand daarvan ga je doorontwikkelen op je toestellen. Alles valt en staat met hoe je je toestel voorziet van sensoren om die data te genereren. Hier moet je vooraf over nadenken, want anders krijg je niet de goede data. Dit moet dus gebeuren bij de productontwikkeling.	Skilled personnel
Auping	toch met serviceproviders. Dus online platforms waarmee je samenwerkt, maar ook onze eigen IT-afdeling. De scanners die we of van dichtbij halen of al in huis hadden. We hebben op dit moment een CRM-systeem waarin alle data wordt opgeslagen. Daarvoor hebben we IT-personeel in dienst die al deze data verwerkt.	Skilled personnel
Nijhuis	de mensen zijn het belangrijkst. Water is een belangrijk goed. Bedrijf is heel hard gegroeid de afgelopen jaren. De mensen zijn jong en idealistisch. Die zien dat we duurzamer moeten worden. Die jagen dat proces aan.	Skilled personnel
ATAG	Daar hebben we binnen onze huidige e-commerce omgeving de mogelijkheid om een module te implementeren die daarbij kan ondersteunen. Daarbij gebruiken we onze huidige e-commerce-software, doordat je dan een plugin extra installeert ook daarvoor gebruikt kan worden.	Infrastructure
ATAG	de processen zullen moeten worden vastgelegd. Hiervoor hebben we procesbeschrijvingen die we standaard hebben. Ook vanwege onze ISO-normen hebben we daar templates voor. Naast die processen leg je ook de infrastructuur en architectuur neer van wat heb ik daar voor systemen voor nodig. Dit leg je allemaal vast. Ook hiervoor heb je een systeemarchitect in huis. Je hebt een soort van spinnenweb met alle systemen en hoe de relaties tot elkaar liggen. Daarnaast hebben we een applicatielijst. Dat is een omgeving waarin alle applicaties in vermeld staan. En we hebben een visuele weergave van alle systemen die we hebben. Dat is een overzicht van alle paketten die er zijn en wat de relaties onderling zijn.	Infrastructure
Auping	De kunst is dus om het product terug te krijgen. Dat lossen we nu op door bijvoorbeeld echt al bij de aankoop in ons CRM systeem hun gegevens achter laten. Zo kunnen wij ze herinneren over een aantal jaar dat het matras dus terug moet.	Infrastructure

ATAG	Je hebt dus een toestel nodig wat kan kletsen met onze omgeving. Die smart appliance is nodig. Vervolgens heb je een omgeving nodig die de data kan verwerken. Je hebt dus een cloud nodig die de data kan opslaan. Dan heb je een omgeving nodig die het betalingsverkeer regelt. En je hebt de mensen nodig die het hele proces kunnen ondersteunen. En deze mensen moeten dus ook goed weten hoe dit in elkaar steekt, voor het geval er vragen over komen.	Infrastructure / Skilled personnel

Appendix 2: summary of the interviews conducted. Sorted to date.

Date: 29 April 2020, Time: 10:00.

Organization 5 - Innovations Manager

Organization five is a contraction company. The company considers itself to be an innovative organization. Contraction companies are normally not that innovative. The organization is creating a vision concerning CE. They are trying to work with more sustainable materials. Eventually, the plan is to build modular buildings that can be deconstructed so that parts of buildings can be reused. The organization has not got a data management strategy yet. The organization is discussing about making use of data management, but since there is no CBM up and running yet, the organization does not consider a data management strategy yet either. They are working with material passports, where data about the composition of building elements is gathered and stored. The most important concern for CE and data management to the organization is that it is not profitable yet. That is why the organization has not implemented these strategies yet.

Date: 30 April 2020, Time: 09:00.

Organization 1 - Sales and Business Development Director

Organization one is an organization that provides hatchery solutions to businesses. The organization tries to make the products they deliver as circular as possible. This is mainly done by gathering large amounts of usage data from the hatchery installations. The data is used to improve processes and efficiency of the machines. Eventually, the organization is planning to change their business model to a service model. No more hatchery machines are being sold, but the service of a hatched egg is sold to customers. The organization is already gathering usage data to be able to switch to this business model in the future. Therefore, usage of Big Data is already present, but not yet in a fully circular business model.

Date: 30 April 2020, Time:13:00

Organization 2 - Innovation Manager

Organization two is an organization that produces household appliances. CE is one of their strategic directions. It has a business model called ‘the circular kitchen’, where kitchen appliances are leased instead of sold. The appliances of the kitchen are equipped with sensors, creating ‘smart products’. These smart products constantly communicate data to the

organization. The data is used for all sorts of purposes. On the one hand the data is used to improve product design, because the sensors measure which parts of a product are used intensely and which ones are not. On the other hand usage data can predict when parts of a product might break, which creates the possibility for predictive maintenance. Both aspects enhance product lifecycle management, which contributes to a more circular economy.

Date: 11 June 2020, Time: 10:00.

Organization 2 - Business Information Manager

This was the second interview with organization two, conducted with the business information manager. This employee is responsible for the 'bridge' between the business and the IT-department of the organization. This interview mainly focused on the digital aspect of the CBM of the organization. He explained about the digital infrastructure of the organization and what was digitally needed to fulfill the IoT technology in their Circular Kitchen Project. He mentioned the need for the right infrastructure and skilled personnel as key features to make such projects work. Gathering large amounts of data is one thing, but analyzing and knowing what to do with it is just as important.

Date: 19 June 2020, Time: 13:30

Organization 4 - Innovation and Technology Director

Organization four is a water recycling company. It delivers water solutions to food and agricultural production companies. Water is a scarce resource, which makes it necessary to recycle it. The organization provides installations that make it possible to recycle water. Just as organization one, this company gathers enormous amounts of data about the processes where the water is recycled. This data is analyzed and used to improve those processes. The organization stresses the need for more regulation to price negative external effects of non-renewable resources, because otherwise it will be difficult to compete with those materials. The organization makes use of smart manufacturing through a cloud, which creates more efficient products, reducing costs and materials used.

Date: 19 June 2020, Time: 18:00

Organization 3 - Business Development Manager

Organization three is a mattress production company. It has recently introduced a fully circular mattress. This raised several challenges which the organization had to cope with. A mattress is a product that should last for about ten years. When a take-back-system is then introduced, it

creates a large amount of uncertainty for the organization. To cope with these challenges, the organization made use of several digital technologies. The most important one is that the organization created a very sophisticated customer relations management (CRM) system, where large amounts of customer data are gathered and stored. This data is not necessarily used to improve the product itself, but does deliver a major contribution to the CBM, because it ensures that the products will come back to the organization after they are worn out. The products are designed modular and several elements of the design have been improved so that they are easier to be reused. Finally, every mattress is equipped with a scannable tag, where all the information about the components and the design of the mattress are stored. This creates the possibility to see exactly, even in ten years, how incoming mattresses could be recycled.

Date: 30 June 2020, Time: 12:00

Organization 6 - Director of Operational Excellence and External Affairs

Organization six is an organization that recycles PET-bottles. The recycling process is completely circular, as the incoming goods are used plastics and the outgoing goods are new plastic products such as bottles or meat trays. The most important aspect of CE for this organization is the cooperation in the supply chain. The organization lobbies a lot, trying to influence suppliers in the value chain. This is necessary to improve quality of the incoming products. The interests of parties in the supply chain are different, therefore it is important for the organization to strive to gain as high quality products as possible. The organization does make use of data to improve their business processes, but this does not necessarily have to do with the circular concepts of recycling.

Appendix 3: Research Integrity Form - Master thesis

Name: **A.F.L. (Alexander) Heijting**	Student number: **4623630**
RU e-mail address: **a.heijting@student.ru.nl**	Master specialisation: **Strategic Management**

Thesis title: Combining the digital and sustainable revolution - How organizations make successful use of data management in order to develop and realize business models for the Circular Economy.
Brief description of the study: This study has investigated the possibilities of data management for circular business models. By interviewing several managers in organizations involved in circular economy, there was tried to get insights in how organizations can make use of data management to develop and improve their circular business models. Technologies like Internet of Things and Big Data Analytics could be of great potential for circular business models. The problems experienced in integrating data management and Circular Economy, and the factors that determine the adoption and success of a comination between the two were researched.

It is my responsibility to follow the university's code of academic integrity and any relevant academic or professional guidelines in the conduct of my study. This includes:

- providing original work or proper use of references;
- providing appropriate information to all involved in my study;
- requesting informed consent from participants;
- transparency in the way data is processed and represented;
- ensuring confidentiality in the storage and use of data;

If there is any significant change in the question, design or conduct over the course of the research, I will complete another Research Integrity Form.

Breaches of the code of conduct with respect to academic integrity (as described / referred to in the thesis handbook) should and will be forwarded to the examination board. Acting contrary to the code of conduct can result in declaring the thesis invalid

Student's Signature:  **Date: 22 august 2020**

To be signed by supervisor

I have instructed the student about ethical issues related to their specific study. I hereby declare that I will challenge him / her on ethical aspects through their investigation and to act on any violations that I may encounter.

Supervisor's Signature: _____Date:

Appendix 4: Consent Form for submitting a thesis in the Radboud thesis Repository

Radboud University Nijmegen (hereafter Radboud University) has set up a thesis repository. The purpose of this repository is twofold:

1. To archive theses for a minimum period of seven years, in accordance with legal requirements (Wet versterking kwaliteitswaarborgen hoger onderwijs, Art. 7.3, lid 5).
2. Wherever possible and allowed, make theses available to potential users inside and outside Radboud University.

This supports the process of creation, acquisition and sharing of knowledge in the educational setting.

The repository serves as an archive in which all theses will be included. This consent form serves to also enable the publication of those theses.

By submission and publication in the theses repository copyright is not transferred. Therefore, students can at any time revoke their consent for publication.

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If the student grants permission to Radboud University to make his/her thesis available within the thesis repository to users inside and outside Radboud University, the student states that:

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- Neither the organization offering internship nor the client of the thesis has any objections against making the thesis publicly available in the thesis repository.

- The student has obtained permission from the copyright holder of any material used in the thesis to incorporate this material as part of the thesis in the theses repository and make it available to others inside and outside Radboud University.

- The student grants Radboud University the right to make the thesis available in the thesis repository for a minimum period of seven years, barring earlier withdrawal by the

student. Permission to make the thesis available to third parties will take effect on the date indicated on this form.

- The student grants Radboud University the right to change the accessibility of the thesis and limit it if compelling reasons exist.

Rights and obligations of Radboud University

- The student's non-exclusive license grants Radboud University the right to make the thesis available to users inside and outside Radboud University.

- Radboud University is allowed to include the thesis, in accordance with legal requirements, in the theses repository for a minimum period of seven years.

- Radboud University can make the thesis freely accessible for users of the theses repository inside and outside Radboud University and allow them to use the thesis for private study and/or educational and research purposes, in accordance with the provisions of the Copyright Act (Auteurswet), with full mention of the name of the student and the location of the thesis.

- Radboud University will ensure that the author of the thesis is listed and make clear that if the thesis is used, the origin must be clearly stated.

- Radboud University will make clear that for any commercial use of the thesis the student's explicit consent is required. In relevant cases, explicit consent of the organization offering internship or the client of the thesis is required as well.

- Radboud University has the right to change the accessibility of the thesis and limit it if compelling reasons exist.

Rights and duties of the user

As a consequence of this consent form a user of the theses repository may use the thesis for private study and/or educational and research purposes, in accordance with the provisions of the Copyright Act (Auteurswet), with full mention of the name of the student and the location of the thesis.

Student number : 4623630
Student name : A.F.L. (Alexander) Heijting

Thesis title : Combining the digital and sustainable revolution - How organizations make successful use of data management in order to develop and realize business models for the Circular Economy.

☐ Yes, I grant permission to make available my thesis with the above title in the Radboud thesis Repository.

~~☐ No, I do not grant permission to make available my thesis with the above title in the Radboud thesis Repository, but the thesis is allowed to make available with effect from …… (temporary embargo).~~

~~☐ No, I do not grant permission to make available my thesis with the above title in the Radboud thesis Repository (permanent embargo).~~

Signature:  Date: 22 august 2020

Appendix 5: Summary

This thesis has aimed to investigate the possibilities of data management for circular business models (CBMs). Since the world is running out of non-renewable resources, it is needed to evaluate alternatives to the take-make-waste principle. Unlike linear economy, where resources are disposed once they are no longer used, circular economy aims to maintain the value of resources by constantly reusing them. This requires changes in business models of organizations. How could these changes towards CBMs be backed by data management? New technologies such as Internet of Things and Big Data Analysis could be very beneficial to the development and implementation of CBMs. What problems do organizations face in the use of data management strategies for their CBMs? And what factors determine the adoption and successful implementation of data management strategies for CBMs? These questions are answered in this thesis. By means of a qualitative research, organizations with CBMs have been interviewed. Problems faced in the implementation and the factors that determine the adoption and success for these strategies have been discovered. This research showed that organizations mainly make use of data management to improve processes and to increase efficiency. Data management strategies are mostly concerned if the organization (and the CBM) can clearly benefit from these strategies.