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EXPLORING FIRM-LEVEL BARRIERS TO THE CIRCULAR ECONOMY

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Exploring firm-level barriers to the circular economy

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Abstract

Circular economy is a concept that unites sustainable development with vast economic potential. Research shows that companies that operate a circular business model can save resources and gain a competitive advantage while also reducing their environmental impact. Despite these benefits, not many companies are operating a circular business model today. There is a need to better understand what deters companies from becoming increasingly circular. In this study, conducted together with the research institute RISE Viktoria, we aim to elicit, organise and describe barriers that are inhibiting companies from reaching increased circularity. To do this, we conduct a structured literature study where known barriers are presented. This is followed by two case studies of Volvo Cars Corporation and Hr Björkmans Entrémattor, where we identify and explain barriers that inhibit new circular initiatives. The report contributes with an overview of barriers that are known by research today, and rich in-context descriptions of important barriers. Among other things, our findings show there is a lack of financial justifications for remanufacturing, and that procurement and outsourcing of design activities makes remanufacturing difficult. Further, we also show how an increase in circularity can contribute to more complex operations.

Table of contents

1. Introduction

Circular economy is a concept that replaces end-of-life with the reduction, reuse, recycling, and recovery of products and materials (Kirchherr et al., 2017). It is seen as a way to simultaneously offer environmental quality, economic prosperity and social equity (Kirchherr et al., 2017). Thereby a circular economy suggests an alternative to the linear value streams of today, where a take, use and dispose logic is replaced with circular flows where material is reused infinitely (Stahel, 2016).

Governments, non-governmental organisations and private companies have shown great interest in the concept of a circular economy over the last years (for example Mathews et al., 2011; The European Commission, 2014; H&M, 2017; IKEA, 2017, Accenture, 2015). The increase in resource utilisation made possible by a circular economy plays a major role in the transition towards a sustainable development.

In addition to sustainability, a circular economy holds a vast economic potential. Some estimates claim that the economic benefit for the European market could be up to €1.8 trillion by 2030 (McKinsey, 2016). The benefits for the individual firm includes an increased resource efficiency by saving material costs, and the possibility to create new competitive advantages (McKinsey, 2015, Webster, 2013). At the societal level, the transition towards a circular economy is associated with the creation of local job opportunities (Stahel, 2016).

Much have been written about the circular economy and its benefits during the last years (Ghisellini et al., 2016). Researchers discuss different aspects of a circular economy, such as a societal macro-perspective, a meso-perspective of eco-industrial parks, and the micro-perspective of the individual firm (Ghisellini et al., 2016). Research on the micro-level mainly includes design guidelines (e.g. Design for Environment or Eco-design) and waste reduction strategies (e.g. Cleaner production), and stress the importance of an alignment of business and environmental goals (Ghisellini et al., 2016). However, researchers that discuss this do not provide an explanation for how this alignment should be realised (Wrinkler, 2011, Van Berkel et al., 1997, Ramani et al., 2010). As stated by Andersen (2007), there is a discrepancy between circular economy enthusiasts that have an ethical environmental perspective, and profit-seeking firms operating in a market economy. In fact, despite all the above-mentioned benefits of a circular economy, few companies are operating circular business models today (McKinsey, 2016).

Companies are free to pursue circular initiatives as they chose, and the upsides are known, yet few companies are making the transition. Either, circular business models are less attractive than they appear to be in present research, or inhibitors or barriers exist that prevent or deter companies from becoming circular. A reasonable question is therefore: Why are companies not pursuing circular initiatives at a much faster rate?

Following the assumption that the circular economy holds the potential claimed by researchers, we investigate what barriers that lie between firms today and a more circular state in the future. Until barriers that prevent circular initiatives from taking place have been properly understood and overcome, the potential of the circular economy cannot be realised. Therefore, an understanding of the different barriers constitutes an important step towards the adoption of a circular economy.

Hence, we formulate our research question as: *what barriers are inhibiting firms from adopting circular economy initiatives?*

Our study of firm-level barriers to a circular economy is divided into one theoretical and two empirical parts. First, we conduct a structured literature search in order to obtain an overview of what is known in the area today. The findings are presented as a list of barriers that have been mentioned and explained by different researchers within the field of circular economy. Then, we conduct two separate empirical case studies in which we elicit, identify and analyse barriers within their context. This is done by the conception of a compelling change, a thought-up circular initiative at each company, around which we are able to identify barriers. The method allow us to verify and enrich knowledge around some previously identified barriers, as well as identify new ones. Finally, we synthesise the theoretical and empirical findings and discuss the results in order to draw conclusions.

The findings are intended to be used in two ways. First, the barriers approach will provide managerial insight for each partnering company by highlighting what hinders the adoption of circular initiatives. This follows the purpose of RISE Viktoria, the institute at which this project is being made, which is to produce industry-relevant research. In

other words, we aim to contextualise the findings for each company to create understanding around what is hindering the circular initiative in their respective organisation. Second, since the study is of exploratory nature, it will serve to generate new knowledge concerning the barriers for the circular economy and contribute to the existing body of literature.

2. Background to the area

2.1. The concept of a circular economy

The circular economy is best described as a further development of the linear economy of today. In today's economy, materials flow in a linear fashion: raw materials are sourced, transported, and manufactured into components and products, which are then shipped and sold to consumers (Stahel, 2016). After consumption, when the product is exhausted, broken, or out of fashion, it becomes waste and no longer carry any value. This linear flow implies either that the access to new raw materials is unlimited, or that later generations will have to cope without them. In a circular economy materials flow in circles instead of linearly. Production is based on used recycled products as input rather than virgin raw materials. Once a product reaches its end-of-life, its value is retained instead of being put on the scrapheap. This way, materials travel in never-ending circles, and earth's resources can be used infinitely.

Out of the many loops or circular material flows of the circular economy, recycling is only one (Potting et al., 2017). Reuse, refurbishing, and remanufacturing are also possible ways of extending the life of a product, or giving it a new one. Recycling is necessary and a key activity in the circular economy, as all products must turn into new raw materials at some point after being worn out. But other types of loops that material and products can go through retain more of the products value, and require less energy consumption (Ganzevles et al., 2017). A narrow loop is better than a larger one. If a product can be restored to its original state by a remanufacturing process, doing so is more efficient than recycling it (Potting et al., 2017).

2.2. Circular Business Models

A business model is the fundamental logic of how a firm creates, captures and delivers value (Osterwalder & Pigneur, 2010). Circular business models refer to business models that at its core adopts the concept of the circular economy. The defining criteria for if a business model can be regarded as circular or not is dependent on the exact definition of circularity that one adopts. In general, the benefits for the firm operating a circular business model include resource efficiency and utilization of retained value of old products through reuse and remanufacturing which reduces the need for new production (Kirchherr et al., 2017).

One archetype of circular business models is defined as Deliver functionality rather than ownership (Bocken et al., 2014). A company should, instead of the traditional manufacturing, distribution, and sales of a product, satisfy user needs without users having to own the physical product. This could for example be done by allowing customers to rent the product as needed instead of having to buy it. This business model comes with a major incentive change in the way that the company captures value. The company will no longer

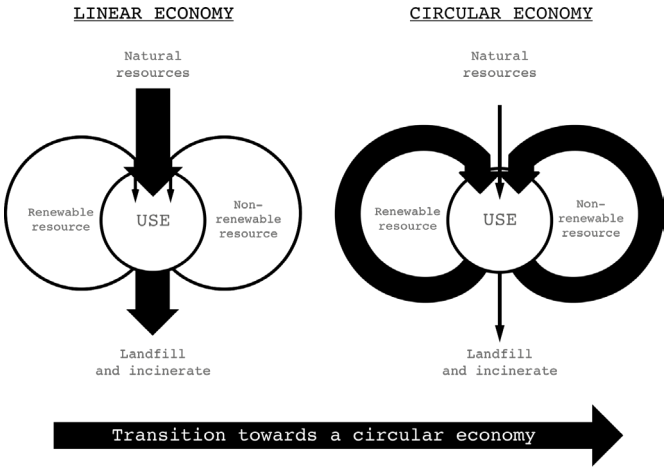

Figure 1: Illustration of the resource flow of a linear and a circular economy (Potting et al. 2017)

profit from selling as many products as possible, but rather through maximising the rentals of the same products. Instead of designing for a limited product life that creates a new sales opportunity, companies will be rewarded by designing products that lasts as long as possible, that are repairable, and easy to dismantle, thus aligning their goals with the ones of a sustainable development.

2.3. Increased circularity

Rather than either being circular or not, a system can have a certain degree of circularity on a continuous scale ranging from fully linear to fully circular. The difference between a linear and a circular flow is illustrated in figure 1. It is important to understand how circular a system currently is, and how that level of circularity is affected by the introduction of changes. In order to do so, an appraisal of the degree of circularity is needed.

One way of doing such an appraisal is to measure the circularity. Several circularity metrics exist that study circularity on different levels. Some metrics, such as the material flow analysis as described by Haas et al. (2015), are aimed at measuring the circularity at a high, societal, level. At a micro level, studying the firm or a single product, the circularity indicator introduced by Linder et al. (2017), can be used.

However, measuring circularity often require detailed data about the products and the organisation, which can be cumbersome to come by and process. An alternative way of appraising the degree of circularity in a system can be done by using a conceptual understanding of the different parts of a circular economy. Potting et al. (2017), present a framework of different strategies that span from a fully linear economy (see figure 2), to a fully circular one. Using this framework, any change that leads to an adoption of a strategy further up in the model, can be said to increase the circularity of the studied system. For example, the increase of remanufacturing of products which otherwise would have been recycled is seen as an increase in circularity. The activity of recycling material is already circular, but as the remanufacturing process spares energy and retains value of the existing product, it results in a higher degree of total circularity. To allow for emergent findings and a wide perspective on circularity, we apply this conceptual framework in our study.

2.4. Remanufacturing

Remanufacturing is a key concept within the circular economy, and also important to the studies of this report. It is by the Remanufacturing Industry Council defined as "a comprehensive industrial process by which a previously sold, worn, or non-functional product or module is returned to a 'like-new' or 'better than new' condition and warranted in performance level and quality" (RIC,

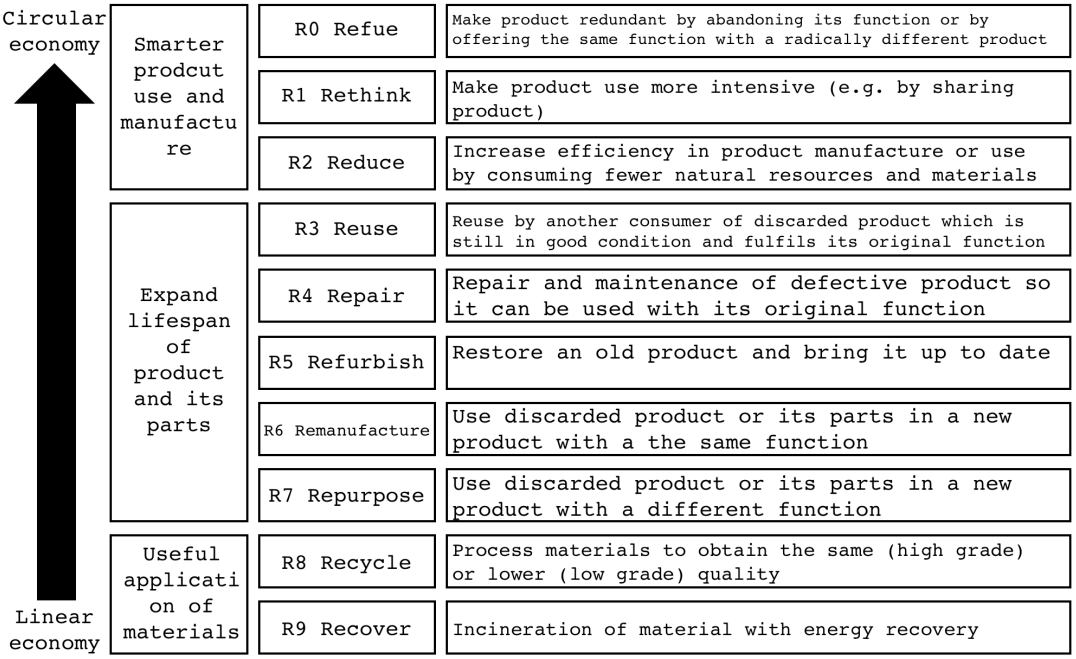

Figure 2: 9R framework (Potting et al., 2017)

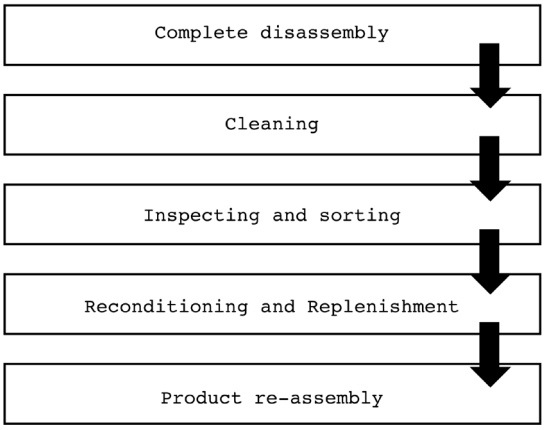

Figure 3: The general steps of the remanufacturing process (Steinhilper, 2001)

2013). This definition separates remanufacturing from related concepts such as refurbishing or repairs since, to achieve this quality level, a more comprehensive process is required. The key difference is that the product is restored to a condition that is as good or better than the original product through an industrial process. In comparison, refurbishment and repair, are concepts that have a less precise definition and can refer to smaller fixes or bigger overhauls. The general steps of the remanufacturing process is illustrated in figure 3.

In addition to the steps found in conventional manufacturing, remanufacturing includes the steps disassembly and cleaning (Steinhilper, 2001). This has required remanufacturers to develop their own techniques for an efficient process. After cleaning, each part must be inspected and sorted in order to distinguish which ones can be used again and which must be replaced. This is followed by reconditioning where mechanical work is applied to the parts to restore them to a new condition. The parts are then assembled before the complete product go into final testing (Steinhilper, 2001). Additional steps that improve the functionality could be included in the process. Examples of such functionality could be adding sensors or upgrading to a more wear resistant material where needed (Matsumoto et al., 2016).

Not all products are fit for remanufacturing. Steinhilper (2001) has developed eight criteria to determine whether a product is well-suited for remanufacturing (see table 1). An industry where remanufacturing is particularly common is the automotive industry (Seitz, 2007). The reason behind this is partly that many of the mechanical products used in a car meet these criteria. It also has a historical reason from when in times of material scarcity were forced to prioritized value retention (Seitz, 2007).

Technical	**Product design for disassembly**
Quantitative	Volume and timely availability of the product
Value	Value added from material
Time	Single life cycle use time
Innovation	Technical up-gradation
Disposal	Efforts and cost of alternative processes to recycle and dispose materials
Alliance	Competition or cooperation with OEM
Other	Market behaviour and intellectual property rights

Table 1: Criteria for remanufacturing suitability (Steinhilper, 2001)

Today when materials are no longer as scarce, companies still remanufacture due to positive effects such as a high profit margin (Lund and Hauser, 2010) or lower cost of input material (Bras and McIntosh, 1999). In addition to the two benefits mentioned above, the main reason for many actors in the industry today reside in serviceability, as remanufactured parts are the only source of spares for older products (Sundin, 2004). The production process for new automotive parts requires high volumes to be profitable and it is therefore not financially reasonable to keep the production for the comparably small and diminishing demand of spare parts (Sundin, 2004). By the collection of objects, actors are able to supply the market with remanufactured parts for a sustained period of time (Lund, 2012).

The market for remanufactured products is mainly comprised of three actors: the original equipment manufacturer (OEM), a contracted remanufacturer and an independent remanufacturer (Sundin, 2004). A contracted remanufacturer performs the work while the object remains in the ownership of the OEM while the independent remanufacturer buys used products to remanufacture and resell

(Hatcher et al., 2011). A review of the dynamics on such a market concludes that there is often a competition for cores between the OEMs and the third-party remanufacturers as well as a cannibalisation on new products (Seitz, 2007).

There exists a potential for a competitive advantage in remanufacturing as value is retained when products that have reached end-of-life are restored to their original working condition (Seitz and Peattie, 2004). This makes the concept of remanufacturing central to many circular business models. This value retention also builds to the fundamental relationship between the process of remanufacturing and a product service system (Matsumoto et al. 2016). The incentive to remanufacture changes when the ownership remains with the supplier. A supplier who previously did not need to be too concerned with the lifetime of the product as long as it met the contractual agreement such as warranty now has an inherent incentive to extend the product life as his revenue is ensured by giving access to the product as a service (Matsumoto et al. 2016).

2.5. Product-Service Systems

A Product-service system is a set of products and services that together fulfill a user's need (Goedkoop et al., 1999). Product-service systems, or PSS, are widely discussed as one of the main steps towards a circular economy (Stahel, 2016), and it is an important concept for this study. The concept is related to closed-loop supply chains, an extension of product life-length, and life-length extending services such as refurbishment or remanufacturing (Mont, 2004). This is mainly due to the shift in financial incentives that follows a change in ownership. As producers retain ownership of their products, factors such as life-length and functional uptime of the product become aligned with the financial incentives of the company.

However, an adoption of the PSS concept does not automatically imply an increase in circularity. There are several different definitions of what a product-service system is. Some include environmental benefit as a criterion, others do not, and no definition is commonly accepted (Mont, 2004). Goedkoop et al. (1999) define a product-service system as:

"a marketable set of products and services capable of jointly fulfilling a user's need. [...] It can enclose products (or just one) plus additional services. It can enclose a service plus an additional product. A product and service can be equally important for the function fulfilment."

A definition such as this one allows for the inclusion of a wide range of product-service combinations into the concept, for example products bundled with financial services such as payment schemes (Mont, 2004).

Some authors therefore argue that a criterion for environmental benefit should be included into the definition of a product-service system (Mont, 2004). This, of course, is not coherent from a semantic point of view, and would be similar to refusing to call a car a car because it is not a low-emission car. Other authors approach this by using the notion Eco-efficient Product-Service System (Ceschin, 2013), or Sustainable Product-Service System (Vezzoli et al., 2015). For the purposes of this project, however, there is little need to delimit the definition of PSS at all, as all limitations comes with the risk of excluding something of relevance. Instead, we adopt a wide definition of PSS, combined with the concept of a circular economy. That is, we study product-service systems, but with the intention of reaching an increase of circularity in the economy. Insights and understanding is drawn from the PSS literature body, but they are applied in the context of circular economy and the possibilities to an increased circularity.

2.6. Barriers

A barrier is something that lies in between and inhibits a desired process from taking place. Using barriers as a construct to study various phenomena is a common approach across a number of research fields. One specific type of barriers are innovation barriers, which loosely inspired the use of barriers of this report. Notable examples are the works of Sandberg and Aarikka-Stenroos (2014) and Assink (2006). The concept of barriers to study organisations is useful as it allows for the identification of specific bottlenecks among the many potential factors preventing innovation from happening (Hölz & Janger, 2013). Using labels for each barrier also has the effect that it divides a field into manageable sub areas. As many concepts are closely related there is a need for a distinguished division in order to get a more clear picture.

Much research has been conducted using a barrier approach. It allows for knowledge that is easy to transfer since framing a finding as a barrier makes the results easy to interpret and test by another researcher. By looking at barriers, we can also focus on what is important and hindering organisations from becoming increasingly circular, instead of looking at inherent challenges and hardships. A barrier is different from a challenge in the sense that it is a clear obstacle to overcome for something to happen whereas a challenge is a constant difficulty regardless of the efforts done to solve it.

Finally, barriers have a high managerial value as they highlight the areas that are inhibiting something from happening. Managers can use the insight to address what causes the barriers and direct more resources to overcoming them. This allows the organisation to develop.

3. Literature study

3.1. Aim

We conducted a literature review in the field of barriers to increased circularity. The study was performed with the aim to provide an exhaustive, yet comprehensible and useful list of barriers that has been identified in previous research. Creating such a list has several reasons. First, compiling what is known in a given field into a list made it more manageable to use when preparing for data collection and while conducting analysis. It allowed us to articulate what we have observed from previous research and what we have not. Second, by following a structured method compiling the barriers, we could be more sure that we have exhausted the field of previous research on firm level barriers for increased circularity. Finally, the list has a standalone value for the reader as it acts as a summary of what is known in the field today.

3.2. Method

3.2.1. Literature search

The literature study was done by a structured keyword search, followed by a reading and sorting of found articles where barriers were identified. These barriers were then organised into groups based on different frameworks using thematic coding. Finally, the different sub-barriers were grouped together using a KJ-analysis to create a manageable set of barriers to be used in both data collection and analysis. The approach we chose for our literature search was inspired by the literature study performed by Kirchherr et al. (2017). In their study the authors set out to unravel the different understandings of the concept of the circular economy and did so by using a pragmatic approach to gather what was known in the field before moving to analysis. We used a similar method where we aimed to generate a representative sample of what is known in the field, and thereafter sift through this sample using own judgement while carefully explaining each step.

We started the literature study by doing a keyword search on Elsevier's Scopus. The keywords were selected with the aim to capture research that had identified barriers that kept companies from reaching an increase in circularity. The search-string was designed as the intersection of two bodies (see figure 4). On one side, keywords relating to concepts of the circular economy (e.g. remanufacturing), on the other side, keywords relating to barriers (e.g. barriers, or inhibitors). The keywords for the search was identified an initial reading of articles and through interaction with researchers in the field of circular economy.

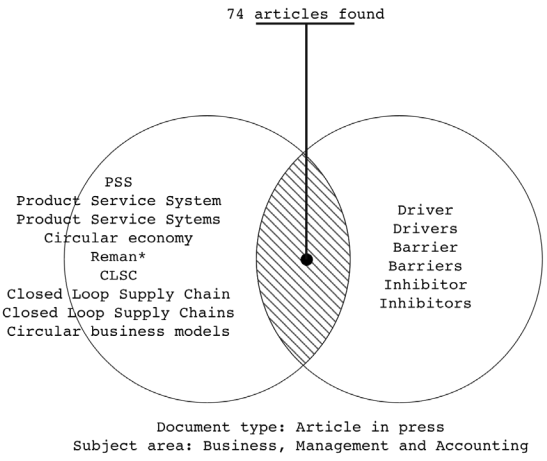

Figure 4: Illustration of the search string used in the literature study

The search string used was: ("PSS" OR "Product service system" OR "Product service systems" OR "Circular economy" OR reman* OR "CLSC" OR "Closed Loop Supply Chain" OR Closed Loop Supply Chains" OR "Circular business models") AND ("Driver" OR "Drivers" OR "Barrier" OR "Barriers" OR "Inhibitor" OR "Inhibitors") AND (LIMIT-TO (DOCTYPE, "ar") OR (LIMIT-TO (DOCTYPE, "ip")) AND (LIMIT-TO (SUBJAREA, "BUSI")).

The search was also limited to peer-reviewed articles and to the subject area business & accounting. The limitation of the subject area was done in order to avoid articles on operational or too detailed technical barriers, as the focus of this study is on overall barriers to increased circularity. 74 articles were found in the search (see table 2).

The 74 articles of the initial search were sifted through manually. Only titles and abstracts were read. Those deemed to contain strategic barriers for increased circularity were read more closely. 43 articles were discarded, leaving 31 to be studied closer.

The 31 relevant articles were read, and barriers mentioned were extracted and listed. 17 articles were rejected after being read more thoroughly as they did not contribute to the area of barriers to a circular economy. In total the results were 14 articles (see table 3), of which 9 articles contained barriers relating to remanufacturing, and 5 to the topic of Product-service systems. 0 articles were related directly to the notion circular economy. An overview of the process of reducing the number of relevant articles is provided in table 2.

Stage of the literature search	Number of articles
Initial Scopus keyword search	74 articles
First sorting based on titles and abstracts	43 rejected, 31 kept
Second sorting based on reading of the articles	17 rejected, 14 kept.
Final result	9 articles relating to remanufacturing, 5 relating to product-service systems

Table 2: number of articles in the different stages of the literature search

In order to achieve a more complete literature search, cited articles were also read as needed. Articles that were cited by the articles of the literature search, were read for a further understanding of the mentioned barriers.

Article	Area
Coreynen et al. (2017)	Product-service systems
Chakraborty et al. (2017)	Remanufacturing
Zhang et al. (2017)	Remanufacturing
Govindan et al. (2016)	Remanufacturing
Sharma et al. (2016)	Remanufacturing
Matsumoto et al. (2016)	Remanufacturing
Hannon et al. (2015)	Product-service systems
Abbey et al. (2015)	Remanufacturing
Zhu et al. (2014)	Remanufacturing
Armstrong et al. (2015)	Product-service systems
Vezzoli et al. (2015)	Product-service systems
Ceschin (2013)	Product-service systems
Mukherjee and Mondal (2009)	Remanufacturing
Guide et al. (2006)	Remanufacturing

Table 3: The final list of articles generated by the literature search

Barriers were extracted from the articles. We read all of the 14 articles and identified barriers related to product-service systems and remanufacturing.

A structured keyword search had the benefit that it served as a useful boundary of our literature study and that it helped us to quickly get a comprehensive picture of what is known in the field. In addition, it allowed us to be sure that we have exhausted the field of what is known and

thus avoiding any evident gaps. By limiting the search to peer reviewed articles we could increase the quality of the literature study since those articles must in turn pass a rigorous examination by other known researchers in their respective field. It must however be pointed out that basing a literature study on keywords always comes with the risk of choosing the wrong keywords excluding valuable articles from the results, or that some authors have use other keywords to describe similar phenomena. To address this issue we worked in a iterative manner trying different search strings and evaluating the results together with experienced researchers in the field.

3.2.2.Coding

To organise the raw data that was extracted from the studied articles we developed a coding framework. First, the data was split into the two top categories of remanufacturing and product-service systems. Then, the data was then coded into barriers using thematic coding. To further structure the data, sub-categories were developed using emergent codes from the data via a KJ-analysis (Kawakita, 1991).

3.2.2.1.A coding framework for remanufacturing

The coding framework for the data regarding remanufacturing was selected after comparing several alternatives (see table 4). Four of the articles from the literature search contained useful categorisations of remanufacturing barriers. We chose to not use a framework based solely on the different physical activities of remanufacturing such as in Sharma et al. (2016), as this would not capture strategic or non-tangible barriers well. Ijomah et al. (2007), categorise barriers into technical and non-technical, which was deemed to be not detailed enough for the purposes of this study, which has the aim to mostly study different kinds of non-technical barriers. The framework used by Zhu et al. (2014) with only two categories was considered as not detailed enough. Finally, Govindan et al. (2017) uses a categorisation of production, business, stakeholder and technical which was seen as the most suitable of the ones mentioned in the studied literature.

Other possible frameworks useful for this coding was considered (see table 4). Such as the business model canvas (Osterwalder and Pigneur, 2010) and the value chain (Porter, 1985). After evaluation by test-coding with some data, the framework provided by Govindan et al. (2017) was selected.

Author	Framework
Ijomah et al. (2007)	Technical, Non-technical
Govindan et al. (2017)	Production, Business, Stakeholder, Technical
Zhu et al. (2014)	Strategic, Operational
Osterwalder and Pigneur (2010)	Key partners, Key activities, Key resources, Cost structure, Value proposition, Customer relationships, Channels, Revenue streams, Customer segments
Porter (1985)	Inbound logistics, Operations, Outbound logistics, Marketing & sales, Service, Firm infrastructure, Human resource management, Technology, Procurement

Table 4: Frameworks considered for the remanufacturing literature review

Definitions for each code was developed. Although the framework in Govindan et al., 2017 was deemed useful, the authors do not provide definitions for each category. Therefore we developed our own definitions for each code in order to help the coding process and create better rigor. The definitions are listed in table 5.

Code	Definition
Production	The carrying-out of remanufacturing activities and other associated activities such as logistics.
Business	Relating to the business logic of the remanufacturing, such as how the firm creates and captures value.
Technical	Barriers relating to technical know-how, existing technologies and the development of new technologies.
Stakeholder	The relation to, and influence by customers, 3rd-parties, governments and NGOs.

Table 5: Definitions of the categories following the framework of Govindan et al., 2017

3.2.2.2.A coding framework for product-service systems

The coding framework for the data regarding product-service systems was selected using a similar process as for remanufacturing. Within the literature search, only one article used a framework for categorisation of Product-service system barriers; Coreynen et al., (2017). After comparing Coreynen et al.'s (2017) framework with other popular frameworks such as the business model canvas and the value chain (see table 6), an article search was made in order to find additional, more suitable, frameworks. The search led us to the framework presented in Emili and Ceschin (2016) which we applied to the data. The framework is constituted by Networks of stakeholders, Products and services, Offer, Customers and Payment channels (see table 7). Initial attempts of coding using the framework revealed the need for an additional code regarding organisational matters which we extended the framework with. It is worth noting that the framework by Emili and Ceschin (2016) was initially created to be used within the context of sustainable energy systems. Still, the framework was deemed the most useful out of available alternatives.

Author	Framework
Coreynen et al. (2017)	Design, Roll-out, Logic
Osterwalder and Pigneur (2010)	Key partners, Key activities, Key resources, Cost structure, Value proposition, Customer relationships, Channels, Revenue streams, Customer segments
Porter (1985)	Inbound logistics, Operations, Outbound logistics, Marketing & sales, Service, Firm infrastructure, Human resource management, Technology, Procurement
Emili and Ceschin (2016)	Network and stakeholders, Products and services, Offer, Customers, Payment channels

Table 6: Frameworks considered for the Product-service systems literature review

Code	Definition
Network of stakeholders	The actors involved in the PSS system. Suppliers, service-provider, government, 3rd parties.
Products and services	What combination of products and services that make up the PSS.
Offer	How the PSS is presented and delivered to the customer.
Customers	How the customer receives, perceives and values the PSS.
Payment channels	How the transaction is made.
Organisation (added as needed)	Concerning the internal stakeholders, how they are structured, and how roles and responsibilities are divided.

Table 7: Definitions of the categories following the framework of Emili and Ceschin (2016)

The coding frameworks developed from Govindan et al., 2017, and Emili and Ceschin (2016) were used to code the data into categories of barriers. Only one category was left empty when the data had been coded: Payment channels from Emili and Ceschin's framework. That category does therefore not appear in the findings chapter.

One alternative to the frameworks presented above is to completely use emergent coding to structure the barriers identified in the literature. We tried this method as a part of our iterative process, as we sought to generate an exhaustive representation of what is known about firm-level barriers for the circular economy. This alternative was rejected on the basis that it would introduce too much bias into the structure, and that we for instance would focus too much on one field at the expense of another. By using an existing framework for the initial categorisation we could increase the transparency and limit the risk for different interpretations of barriers. When the initial categories where set we proceeded to an emergent categorisation for the sub-barriers. This method will be explained in the following section.

3.2.3.Affinity diagram

To further analyse and sort the data into more well-defined categories a KJ-analysis, also known as the affinity diagram (Kawakita, 1991) was used. The method is a way to organise disorganised qualitative data and information into groupings based on natural relationship. The diagram is created in three steps: first, each piece of data is recorded on a card or note; then, details are looked for and data that seem to be related; last, the cards are sorted into groups until no more remain.

This resulted in a number of sub-barriers, each constituted by data on barriers by several authors that were seen as related. For example, Ownership is norm, cultural status attached to ownership, and customers prefer owning products, are all three statements from different authors of the literature search that are related to customer attitudes towards product-service systems, and could therefore be categorised together.

The grouping and consolidation resulted in 13 barriers relating to remanufacturing and 8 barriers relating to product-service systems.

3.3.Findings

The following barriers were identified in the literature search. The barriers are categorised as belonging either to the field of remanufacturing or product-service systems. A full overview of the identified barriers is displayed in table 8.

3.3.1.Remanufacturing

The following barriers have been compiled from the literature study within the field of remanufacturing.

3.3.1.1.Reverse supply chains are challenging

For the remanufacturing process to start, the end-of-life products must be returned from the customer to the remanufacturer. This is an activity that has proven to be challenging for many industries (Ghoreishi et al., 2011, cited by Sharma et al., 2016). Rashid et al. (2013), via Govindan et al. (2017), claim that the absence of optimized reverse logistics makes remanufacturing in itself difficult. The current reverse supply chain is for many organisations not adapted for the small scale and uncertain flow of cores returned. King and Burgess, (2005), via Govindan et al. (2017), add that the high cost of collecting the cores from each customer may consume much of the potential profit for the remanufacturer. Another factor contributed by Chakraborty et al. (2017) is the lack of coordination between the actors in the reverse supply chain and that information and knowledge sharing is important for the supply chain to function.

3.3.1.2.Long lead times and uncertain processing time

There are several uncertainties within remanufacturing. The amount of cores that are returned from customers varies (Chakraborty et al., 2017, Mukherje and Mondal, 2008). The quality of the cores that have been returned is also uncertain (Mukherje and Mondal, 2008) as the state that they are in is dependent on the environment that they have been exposed to during use (Amezquita et al. 1995; Guide 2000). Further, the lead-time of the remanufacturing process is also uncertain, and dependent on the design of the product (Ijomah et al., 2007, via Govindan et al., 2016). The different processing steps such as disassembly and cleaning are affected by how well-suited the product is for those steps and how easily and quickly the operator is able to go through the process. Finally, the demand for remanufactured products is also an uncertain variable, which makes it difficult to plan for and assess remanufacturing in advance (Ijomah et al., 2007, Choudhary et al., 2011, via Govindan et al., 2016).

3.3.1.3.Low availability and high cost of replacement parts

The remanufacturing process requires spare parts that can replace those that have been worn down during use. The availability and the cost of these spare parts can constitute a barrier that inhibits remanufacturing (Hammond et al., 1998, cited by Govindan et al., 2016). Because of a vast increase in the number of product models and versions, spare parts have a great diversity which makes it hard and costly to supply them into the remanufacturing process.

3.3.1.4.Lack of measurability

Remanufacturing is difficult to measure in several aspects. There is a lack of data regarding remanufactured products' quality and environmental performance (Subramoniam, 2009, via Govindan et al., 2017), especially data that considers the full life cycle of the product (Saavedra et al., 2013, via Govindan et al., 2017). The availability of this information could aid companies in their decision making process regarding remanufacturing and make it significantly easier to assess remanufacturing business opportunities (Govindan et al., 2017).

Area	Category	Barrier
Remanufacturing	Production barriers	Reverse supply chains are challenging
	Long lead times and uncertain processing time	Low availability and high cost of replacement parts
	Business barriers	Lack of measurability
	Lack of life-cycle perspective	Lack of marketing strategy for remanufacturing
	Lack of business case	Cannibalisation
	Stakeholder barriers	Presence of counterfeits and secondary markets
	Unsupportive government and regulation	Customer dislike and lack of understanding
	Technical barriers	Absence of advanced remanufacturing technology
Product-service systems	Lack of expertise	Barriers related to network of stakeholders
	Conflicting interests in the value chain	Unsupportive regulatory framework
	Barriers related to products and services	Increased operational complexity
	Barriers related to the offer	Product service systems are difficult to measure
	Barriers related to customers	Customers prefer owning products
	Insufficient trust and privacy	Barriers related to organisation
	Product-service systems require a big organisational change	New skills and knowledge required

Table 8: Barriers identified in the literature study

Further, this lack of information also acts as a barrier for customer acceptance of remanufacturing, and in extension the demand for remanufactured products (Michaud et al., 2011, via Zhu et al., 2014). As remanufacturing cannot be quantified, customers have difficulties understanding that it is beneficial for the environment and that the remanufactured products have the same quality standard as new products.

3.3.1.5.Lack of life-cycle perspective

Companies may, according to Ijomah et al. (2007), have a short-sighted perspective which acts as a barrier to remanufacturing. The findings of Ijomah et al. (2007) show that products may sometimes be designed for the purpose of only lasting a single life, and that maintaining high quantities of new sales are seen as more important than the possibility of selling remanufactured products. Examples of this includes using less durable materials, and not designing products so that they can be disassembled. Products that are made of less durable materials can only be used one life-cycle, and do not endure the remanufacturing process. However, the cost for those products is usually lower. Designing for disassembly is costlier, but is needed for remanufacturing as it is a core activity in the remanufacturing process.

Adding to a short-sighted perspective is also what Subramoniam, 2009 (cited by Govindan et al., 2017), calls a mass production mentality. As remanufacturing is of high uncertainty, a slower process, and of lower numbers than new production, it is not prioritised or seen as important within companies.

3.3.1.6.Lack of a marketing strategy for remanufacturing

There is, according to Sharma et al. (2016) (citing Majumder and Groenevelt, 2001, and Östlin, 2009), a lack of a marketing strategy for remanufacturing. This lack of strategy inhibits the development of further remanufacturing as it leads to a low level of knowledge and demand for remanufactured products. The authors further claim that companies with an ill-developed pricing strategy price remanufactured products too low. Thereby, those companies fail to capture the potential profit of remanufacturing.

3.3.1.7.Lack of business case

Business cases for remanufacturing are difficult to analyse. There is, according to Subramoniam, 2009 via Govindan et al., (2017), a lack of a remanufacturing business case analysis model to assist business managers in their decision making. Because of this, managers make late decisions that are based on the volume of remanufacturing rather than the business value.

The business case for remanufacturing is further complicated by a fluctuating demand (Ijomah et al., 2007, Choudhary et al., 2011, via Govindan et al., 2016), an uncertain influx of used products (Chakraborty et al., 2017) and a corresponding difficulty in forecasting of remanufacturing activities (Zhang et al., 2017).

3.3.1.8.Cannibalisation

Concerns that cannibalisation will reduce the sales of new products is also regarded as a business barrier for remanufacturing. As reported by Zhang et al. (2017) some companies worry that increasing their remanufacturing capabilities will have a bad effect on the sale of new products. This concern for cannibalisation is confirmed by Atasu et al. (2008) (via Matsumoto et al., 2016) which can lead managers to not remanufacture at all or to redirect remanufactured products to invisible or secondary markets.

3.3.1.9.Presence of counterfeits and secondary markets

The reputation of remanufacturing can be negatively affected by poorly done repairs by third parties. Zhu et al. (2014), state that low quality of superficially repaired products that are sold as remanufactured damages the reputation for real remanufactured products. Zhang et al. (2017) support this, stating that one of the main challenges for remanufacturing is counterfeit products that are disrupting the market. However, the degree to which these findings can be generalised outside of the Chinese market is unknown.

Another problem identified in the truck industry, is when used trucks are sold to secondary markets to never to return to the original vehicle supply chain again (Zhu et al., 2014). This puts the products out of reach for the OEM or an affiliated third party remanufacturer and thus disrupting the availability of cores to support the remanufacturing business.

3.3.1.10.Unsupportive government and regulation

The government is an important stakeholder in the remanufacturing industry because of the regulatory power it possesses. The role of governments is to guide, promote and enforce producers to undertake an environmental responsibility (Zhang et al., 2017). This barrier appears to have a local aspect as the developed countries have come further in the policy making that concerns remanufacturing (Govindan et al., 2017). Ijomah

et al. (2007) report that when governments ban the use of certain materials it could eventually lead to some products being impossible to remanufacture although it is better from an environmental perspective. In other instances it has been seen that end-of-life regulations can have a negative impact on remanufacturing opportunities. In the specific case of Chinese regulations, the order that every car must be sent to recycling is clearly detrimental for remanufacturing as this limits the source of used products, according to Zhu et al. (2014).

3.3.1.11.Customer dislike and lack of understanding

Customers may have a negative mindset towards remanufactured products (Chakraborty et al., 2017). Hazen et al. (2012) (via Zhu et al., 2014) found a direct relationship between a customer's tolerance for ambiguity and their willingness to pay for a remanufactured product in their study. They claim that the ambiguity inherent in the remanufacturing process enforced consumers' perceptions of poorer quality and reduced their willingness to pay for products. Even when the quality of the product is the same or even better, in the eyes of the customer the remanufacturing process was considered a source of ambiguity. Customers may experience this uncertainty, since they do not know how the product was used in the past and what procedures the remanufacturer has carried out to restore the product to its like-new condition. There is also the possibility that some customers do not believe that the product is truly restored to the like-new condition.

Customers may also experience emotions of repulsion or disgust towards certain remanufactured or reused products (Abbey et al., 2015a). Many consumers have deeply rooted beliefs that remanufactured products are disgusting which impacts their desire and willingness to pay for a product. The fact that new products not necessarily are cleaner than remanufactured as they also are handled by human operators and stored on warehouse shelves does not seem to matter for these consumers (Abbey et al., 2015b).

Customers overall disgust towards remanufactured products differ between different product categories (Abbey et al., 2015b). Disgust or repulsion towards remanufactured products increase as the use of the product is within closer distance of the body of the consumer. Products which are used on the body, such as an electric razor, are often met with high disgust if remanufactured. Further, products that are used in the body, such as an electric toothbrush, are met with even higher emotions of disgust.

In extension, this possibility of evoking emotions of disgust among customers acts as a risk for companies. Initiating remanufacturing alternatives may fail, but they may also have a negative impact on the whole brand of the company (Abbey et al., 2015b).

Zhang et al. (2017) add to the customer barrier that most consumers cannot differentiate between remanufacturing and refurbishing and regard these processes as equal. While remanufacturing is a process of industrialised character which restores the product to a "like new" condition, refurbishing can refer to activities of very different extents. This is further supported by Abbey et al. (2015b), who state that customers may not always regard remanufactured products as environmentally friendly, indicating that knowledge and understanding of the process and its impact is low.

3.3.1.12.Absence of advanced remanufacturing technology

Xiang and Ming (2011) mention the absence of advanced remanufacturing technology making the process of waste liquid collection, dismantling and cleaning difficult. It is more common that remanufacturers employ a large number of workers than focus on developing advanced technologies. Although the remanufacturing process is an inherently labor intensive process there are parts of the process that requires specific technology. Chakraborty (2017) reports that an absence of such technologies can hamper the development of remanufacturing as an industrial process. Examples of such equipment are crack detection devices or item tagging to monitor the quality of each component. Another reason for the absence of proper remanufacturing technology is that some machines and equipment are product specific and carefully kept by the OEM from independent remanufacturers (Tian et al. 2014). Within such equipment remanufacturing is in some cases not possible at all. The technology barriers for the remanufacturing process mentioned above are listed in literature all based on studies of underdeveloped parts of the remanufacturing industry such as in China and India.

3.3.1.13.Lack of expertise

Remanufacturing can sometimes take place long after a product was put on the market. And as Barker and King (2007) report, companies can therefore face situations where there simply are no workers around knowledgeable enough to carry out the operations. If the volumes are low as well, the incentives for the remanufacturer to retrain workers could be weak. The nature of the remanufacturing process also calls for a broad set of skill as the study made by Hammond et al. (1998)

found when surveying remanufacturers. Not only do they need to handle a diverse set of products but also mastering many different techniques for disassembly and assembly, two key steps in the process. Without skilled labor available the opportunities to start the remanufacturing of a product can be hampered.

3.3.2.Product-service systems

3.3.2.1.Conflicting interests in the value chain

There may be conflicts of interests within the value chain that hinders PSS adoption. Vezzoli et al. (2015), cite Cooper and Evans (2000), stating that the members of a value chain might have conflicting interests when it comes to the introduction of a PSS. Manufacturers that are operating on a saturated market have the need to maintain high levels of demand to continue production (Cooper and Evans, 2000). Producing companies are reliant on replacement purchases and slight modifications to existing models in order to induce sales (Cooper and Evans, 2000). Further, this has led to the generation of consumer desire and consumerism (Thompson and Holt, 1997, cited by Cooper and Evans, 2000). The introduction of a PSS innovation that reduces the need for new products due to more efficient need fulfilment can be in conflict with interest that aims to increase sales volumes (Vezzoli et al., 2015). A company wanting to adopt a PSS may therefore be hindered and experience a lock-in due to the dependency on other actors within the same value chain.

3.3.2.2.Unsupportive regulatory framework

The environmental benefits are something widely discussed when studying PSS. The concept of Product-service Systems are associated with a development that successfully can combine economic, ecological and social needs (Wilson et al., 2009; Boons and Lüdeke- Freund, 2013 via Hannon et al., 2015) through provision of the final functionality for the consumer (Tukker and Tischner, 2006). However, concerns have been raised that government policy fails to internalise such environmental impacts and reward sustainable business activity in the form of a PSS (Hannon et al., 2015). PSS offers have a positive benefit on the environment in comparison to traditional product sales, but this is not reflected in their pricing. This argument is supported by Ceschin (2013) claiming that environmental innovation is often not rewarded at the company level due to lack of internalisation of environmental impact. Mont and Lindhqvist (2003) (via Vezzoli et al., 2015) elaborate on the internalisation of environmental externalities. If the price of different offers would reflect their respective environmental impact, environmentally inferior products and solutions would be sifted out, which could benefit products-service offerings. As long as this is not the case, the current regulatory framework could be regarded as a barrier for PSS adoption.

3.3.2.3.Increased operational complexity

The transition from product sales to a product-service offering usually increases the complexity of the operations of the provider (Ceschin, 2013). This has to do with the fact that the providing company now has to manage the product also after the point of sale (Ceschin, 2013). While previously having to manage the product to the point of sale and delivery to the customer, the provider now has a long-term commitment and involvement regarding the product. This increases the amount and complexity of operations that the provider has to carry out. This can also be illustrated by viewing Product-service systems as a form of outsourcing of activities (Mont, 2004 via Ceschin, 2013), where the provider takes over some of the activities that were previously managed by the customer, thus increasing the amount and complexity of its own operations.

3.3.2.4.Product-service systems are difficult to measure

The benefits of a Product-service offering can be difficult to evaluate and appreciate due to it being difficult to measure. This difficulty of quantifying PSS offers regards both the provider, the customer and the environment. It is difficult for firms to quantify the savings that arises from a PSS in economic terms (UNEP, 2002 via Vezzoli et al., 2015). It is also difficult for firms to assess PSS business models and different business scenarios (Coreynen et al., 2017). This makes it challenging to market initiatives within the company and to different involved stakeholders that are needed to deliver PSS offers.

Key Performance Indicators (KPIs), metrics and incentive systems may not be well-suited for Product-service systems (White et al., 1999, via Vezzoli et al., 2015). Because of this, the company may not be able to capture and assess the value of the Product-service system. One example of this may be a commission per sold item that the company's salespersons receive. The transition into contracts operating over an extended period of time may render such commissions irrelevant.

The difficulty of measuring also applies to environmental gain (UNEP, 2002, via Vezzoli et al., 2015). A introduction of a PSS might result in a lower total environmental impact for the company, but this may not be noticed due to the current

KPIs and metrics that the company uses regarding its environmental impact.

The value provided and the communication towards the customer is also affected by the difficulty of quantifying the benefits of a Product-service system. To be able to appreciate the value that a Product-service system brings, a more sophisticated understanding of costs is needed than what is typical for the conventional seller-buyer relationship (White et al., 1999, Mont and Lindhqvist, 2003, both via Vezzoli et al., 2015). While buying a product requires understanding and appraisal of the price of the product and a comparison of competing alternatives, contracting a PSS requires an understanding of the total cost of ownership. This includes the cost and benefit of the product, and the cost and value of the internal activities which are being replaced (White et al., 1999, via Vezzoli et al., 2015). It is, for example, easier for a customer to compare the price of different power tools, than it is to assess how a renting scheme of tools will affect his or her total-cost-of-ownership and potentially reduce time delays due to malfunctioning tools.

3.3.2.5.Customers prefer owning products

Preferences towards Product-service systems are different in the business-to-business relations (B2B) and business-to-consumer relations (B2C) (Catulli et al., 2013, via Vezzoli et al., 2015). While the PSS concept has been widely adopted within the B2B context, end-consumers are more reluctant (Catulli et al., 2013, via Vezzoli., 2015). At its simplest form, a PSS in a B2B setting is the same as a traditional outsourcing activity (Mont, 2004, via Vezzoli et al., 2015), and there are several bodies of literature that cover and explain the topic more carefully.

For end-consumers, there are several factors related to the traditional relationship between user and product that acts as barriers for PSS adoption. First, the very start of the user experience differs as a PSS lacks the traditional shopping experience that many customers appreciate (Richins, 2008 via Armstrong et al., 2015). In addition, private users value owning products because it gives them a sense of status, image and control (James and Hopkinson, 2002, Behrendt et al., 2003 via Hannon et al., 2015) and that the owned quantity of goods is itself seen as a status indicator (Mont, 2004, Catulli, 2012, via Vezzoli et al., 2015). End-customers may also simply prefer the traditional ownership of products, and are therefore not interested in the concept of a Product-service system (Rexfelt and Hiort af Ornäs, 2009, via Vezzoli et al., 2015).

3.3.2.6.Insufficient trust and privacy

The development of Product-service systems has an impact on the customer relationship (Mont, 2004, via Vezzoli et al., 2015). Usually it requires closer collaboration between the parties when delivering a Product-service system. This need for collaboration may act as a barrier to PSS adoption for several reasons. First, actors may have a fear of sharing sensitive information such as processes or technologies with each other. The insight by the PSS firm into the lives or operations of the customers may act as a barrier as it leads to less privacy (Mont, 2004, via Vezzoli et al., 2015). Also, handing over parts of the own operations may cause the customer to experience a reduced control and influence which requires more trust in the relation (UNEP, 2002, via Vezzoli et al., 2015). It also becomes increasingly difficult for the customer to assess whether the service meets their needs.

3.3.2.7.Product-service systems require a big organisational change

The transition from selling products to offering a Product-service system constitutes a big change for the firm. Organisations that previously created value through a linear model of one-time sales of products, may struggle on several points when trying to offer Product-service system solutions (Coreynen et al., 2017, Vezzoli et al., 2015).

In fact, the change towards Product-service systems require more than the implementation of a new business model and new offerings (Tukker and Tischner, 2006, via Ceschin, 2013). The culture of the company must be changed and adapted (Martinez et al., 2010, via Vezzoli et al., 2015). Today, the mindset of employees might not be compatible with the logic of PSS (Martinez et al., 2010, via Vezzoli et al., 2015) and people may have a preference towards physical products in that that they prefer physical features and mistrust or misjudge service offerings (Gebauer et al., 2005, via Coreynen et al., 2017). A lack of organisational commitment (Bartolomeo et al., 2003, via Vezzoli et al., 2015) and internal conflicts (White et al., 1999, via Vezzoli et al., 2015) are also inhibiting the adoption of Product-services systems. Further, there may also be an aversion towards PSS offers as they change existing and well-known business models and cash flows (Mont, 2002, and Mont, 2004, via Vezzoli et al., 2015). Instead of up-front revenue at the point of sale, Product-service systems creates smaller long-term cash flows, which is a big change for the organisation.

3.3.2.8.New skills and knowledge required

To offer Product-service systems, new skills, methods and knowledge is needed within companies (Coreynen et al., 2017 and UNEP, 2002, via Vezzoli et al., 2015). Many product producing companies have innovation processes that are technology-centered and happens “in the back”, far from customers, whereas services are developed and co-created in close collaboration with customers (Coreynen et al., 2017). Further, there may also be an unwillingness to learn or apply service skills (Matthyssens and Vandenbempt, 2010, Ulaga and Reinartz, 2011, via Coreynen et al., 2017), a phenomenon relating to the previously mentioned preference for physical products and technology (Gebauer et al., 2005, via Coreynen et al., 2017).

4. Method

This section elaborates on the aim of the empirical study and how this formed the research strategy and the research design. It is followed by an outline of the different steps for data collection and the consequent analysis. Reflections on the choice of method is provided along the way.

4.1. Aim of the study

This empirical study aims to understand barriers that inhibit companies from becoming increasingly circular. The study explores, describes and creates understanding around barriers by studying them in real life. Further, we identify new previously unknown barriers. By doing so, the overall understanding will be increased about what is hindering companies from realising the potential of circular initiatives.

While developing the aim of the study we reflected on the balancing act between setting out to solve a problem and filling a knowledge gap (Edmondson and McManus, 2007). The position on this continuum will guide the rest of the research and it was therefore an important part of the early phase of this study. Focusing too much on knowledge gap may render the research irrelevant for practitioners, while focusing too much on problem solving may lead to results that are not generalisable and short lived. It was with this model in mind we developed the research strategy of our study.

As this is an area where little is known, it places our project closer to the knowledge gap filling side of the spectrum. However, drawing upon the work of Andrew Van de Ven on Engaged Scholarship we aspire to not only develop new theory but also achieve useful learnings for the organisations studied (Van de ven and Johnson, 2006). This veered the direction of our study slightly to the problem solving side of the continuum. We have throughout the study tried to maintain relevance, creating a result that is of benefit for the studied companies.

4.2. Research design

Based on the aim of the study we formulated a research strategy to provide us with a general direction in our project, including the process by which the research is conducted (Easterby-Smith et al., 2015). To do this we started from the purpose of the study and then considered the type and availability of the information required to fulfill that purpose.
The research strategy was also partially determined by the characteristics of the phenomena of barriers. Since the one fundamental meaning of a barrier is something that restrains progress towards a future state of innovation. We hypothesized that if there are no initiatives present it will also be no barriers to obstruct them. Therefore, to identify barriers to increased circularity and circular initiatives, we must study these initiatives regarding them as potential pathways for innovation. How to find such an initiative and coming up with the best way to study it will be covered in the next section Research Design.

We chose to use a qualitative study as it according to Easterby-Smith et al. (2015) is useful for research when trying to understand the specific issues in a given field. Although it would have been possible to perform a quantitative study of the barriers for the circular economy, we deemed this approach as too focused on known barriers and would not elicit emergent barriers. Regarding firm-level barriers as a novel and expanding field to study, this approach is supported by Easterby-Smith et al. (2015) as suitable when attempting to create new knowledge.

We have also chosen to use a case based approach for this study. Following the definition of Easterby-Smith et al. (2015) a case method is a research design that focuses in depth on one or a small number of organisations, events or individuals. In this study, the study objects are represented by the partnering organisations. The choice of using a case based approach to study this topic has several reasons. First, new and unknown fields are best studied with this method (Eisenhardt, 1989). Second, it allows for the phenomena to be studied in its natural setting. Third, this allows for the creation of managerially relevant information as it is carried out in close interaction with practitioners (Amabile et al., 2001). This is something that ties back to the purpose of RISE Viktoria as a research institute, which strives to generate knowledge relevant for the industry (RISE Viktoria, 2017), and to the purpose of this report.

As barriers are associated with change and new initiatives, our method required the study of a change. In search of a suitable change to study, we considered historical ones, current initiatives, and theoretical changes. Using a historical initiative

had the potential to provide the study with rich and relevant data. However, as circular economy is a fairly novel field, identifying suitable historical changes proved difficult. Also, learnings from past changes may be of less relevance for the studied companies.

The second option was to find a present change. This would have allowed us live insight in the change process and rich data as people would have the information in fresh memory. This option, we deemed to have practical constraints such as gaining access to a suitable project within the given time period. Therefore in order to be as relevant as possible, while still keeping within the boundaries of what we are able to realise, we chose to formulate a thought-up initiative, and study barriers that arose in discussion around that change. This method of studying a theoretical initiative that would lead to an increased circularity we decided to call the compelling change method. By generating a compelling change in collaboration with each organisation and build the data collection on questions of how that could be implemented we saw an opportunity to unveil associated barriers within each organisation.

4.3. Selection of companies

The selection of case companies was made from a list of partners engaged in other projects concerning circular business models at RISE Viktoria. This previous engagement was seen as a proof of both interest and commitment in taking part in research projects. Another practical benefit was that before the start of the project each company had a contact person that was in regular contact with RISE Viktoria who could pass us on to key respondents. By selecting companies in this way we aimed to resolve the issue of trust in case studies brought up by Easterby-Smith et al. (2015). They argue that in case studies researchers are often too detached to a company to generate enough trust from the respondents to collect reliable data. We addressed this issue by utilizing the recognized name of RISE Viktoria and building on existing relations thereby we were able to build enough trust with each respondent to generate fruitful and reliable data.

Further, the two companies were also selected as they already were partially circular. Both companies has for a longer period of time been operating circular business models. It was hypothesized that this would lead to more interesting findings. While a company that is completely new to circular initiatives likely has problems with the very most basic barriers, we believed that the study of two rather experienced organisations could elicit more complex and interesting findings to create nuance around existing barriers and uncover new ones.

Finally, the selection of the companies were also done for them to complement each other. In order to be able to explore as many barriers as possible, we selected two very different companies. The companies vary in size and are also circular in different ways; while one deals with remanufacturing, the other operates a product service system.

4.3.1. Volvo Cars Corporation

Volvo Cars Corporation, hereinafter called VCC, is a car manufacturer that separated from Volvo Group AB in 1999 when Ford Motor Company acquired the car division of the company. In 2010 the ownership was transferred to Geely Holding Group, a Chinese multinational manufacturing company with several brands in their portfolio. A brief overview of the company is displayed in table 9.

Volvo Cars Corporation	
Employees	~30 000 (2016 average)
Revenue	MSEK 180 672
Output	534 332 cars (2016)
Manufacturing sites	Sweden 1, Belgium 1, China 3

Table 9: An overview of Volvo Cars Corporation

The data collection at VCC was initiated by meetings with people working with remanufacturing at the Torslanda site. The function was previously a separate team but is now dispersed over a number of units that all go under the Global Customer Service division. At VCC, we had regular contact with a Global remanufacturing manager. Through this contact we were able to get in touch with the necessary respondents to support the data collection of the project.

4.3.2. Hr Björkmans Entrémattor

Hr Björkmans Entrémattor, HRB, is a small company based outside Malmö in Sweden (see table 10). Since 1993 have they operated a business model of offering clean mats to their customers on a subscription basis. The company has grown throughout the years mainly through acquiring washing establishments in other regions.

Part from operating a business model that has potential to be environmentally friendly HRB also has taken several environmentally friendly initiatives that affecting various parts of the business. It spans from biogas powered delivery cars to a closed water management system retaining water from rain and using mats made from recycled materials.

The collection and delivery of entrance mats puts a geographical limit to HRBs entrance mats business. The customer cannot be too far away nor dispersed for it to be viable to collect the mats both from an environmental but also from a financial perspective.

Hr Björkmans Entrémattor	
Employees	~ 35
Revenue	MSEK 39
Presence	Skåne, Småland, Göteborg, Stockholm, Kalix

Table 10: Hr Björkmans Entrémattor at a glance.

4.4. Circularity at the start of the project

Common for both companies included in the study is that they at the start of the project already had some form of circularity in the business model. In the case of VCC it is the business of remanufacturing car components and in the case of Hr Björkmans entremattor it is the PSS business model where clean mats are provided on a subscription basis to customers in the local area.

4.5. Finding a compelling change

In order to elicit barriers for an increased circularity we decided to use a method we named compelling change as explained above. This compelling change was developed in collaboration with each company and was used to build interview questions in the data collection. The reasoning behind the compelling change method is to find a change that can unveil as many of the barriers from the literature review as possible. To do this, we ourselves engaged in the process of developing the suggestions. We then could exclude those suggestions that were too small so that very few barriers would be observable and those to large and complex to generate any reliable data. It was also important that the compelling change truly led to an increased circularity and since the representatives involved had no or little experience in the field we had to make sure that this objective was met as well.

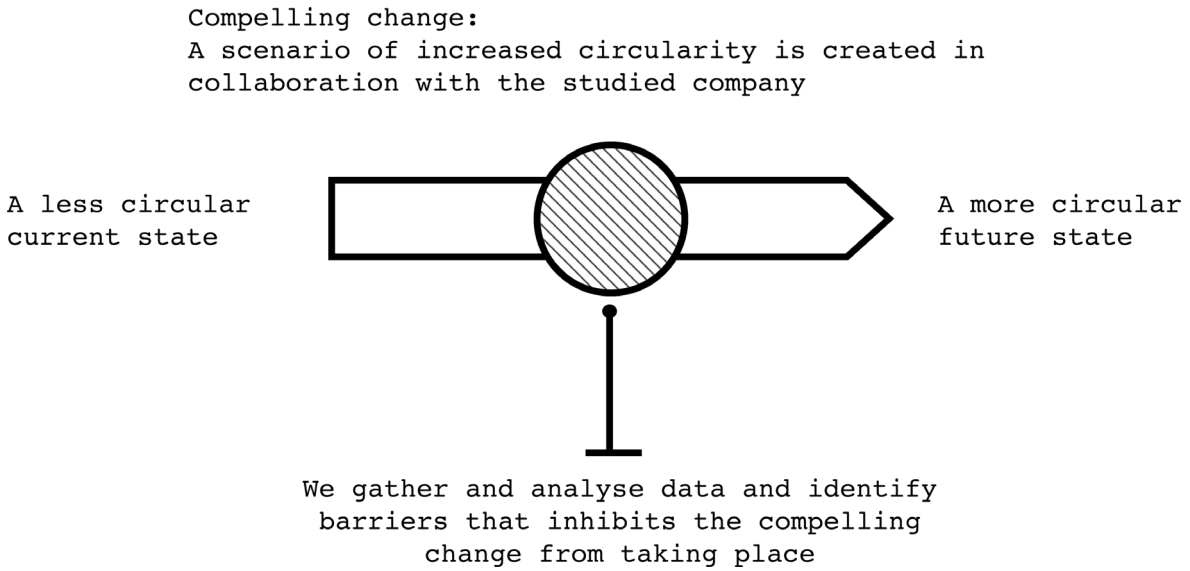

Figure 5: A conceptual model of the research design

Part from unveiling as many barriers as possible, the compelling change must also be relevant for the company. This was important since we wanted to collect reliable data. A compelling change closely related to the company's business objectives was deemed to create engagement from the respondents which would facilitate our data collection. A conceptual model of the relationship between the change and the barriers is illustrated in figure 5.

4.5.1.VCC

The compelling change was at VCC generated by using a workshop. We chose to use a workshop process to find the compelling change as we wanted to ensure that the change would be relevant as well as feasible from VCC's perspective. In addition, we wanted to engage VCC in the process as we believed it would benefit the following data collection.

There were seven participants in the workshop. Four VCC employees participated: one from the remanufacturing department, two from the environmental department, and one employee working with innovation initiatives. A senior researcher in the field of circular economy from RISE Viktoria also participated in the workshop. Finally, the authors participated and facilitated the workshop.

The workshop was performed in four stages roughly following the structure of a workshop guide from the book Sprint! (Knapp et al., 2016). The first stage served the purpose of mapping out the current situation of remanufacturing at VCC. It was drawn out on a whiteboard in collaboration with representatives from VCC. After the mapping was done the group was asked to point out areas of improvement phrasing the questions in a "how might we" format (IDEO.org, 2015). Framing a problem as an opportunity for improvement makes it easier to come up with solutions for it in the next stage of the workshop. The third stage involved idea generation by each participant individually. These ideas were put on Post-it notes and placed on the map next to the respective area for improvement. The final stage was the voting process where each participant was allowed to place a total of three stars on the ideas they found most compelling. The idea with the most votes were selected and the workshop was complete. We followed up on the result by summarising our interpretation of each idea and verified it with each workshop participant, by email.

4.5.2.HRB

The selection of a compelling change at HRB was carried out in a session together with the CEO of the company. The size of the company and the CEO's relative knowledge compared to the rest of the employees motivated this process. By walking through the steps in Porter's value chain (Porter, 1985) we discussed what changes could be made in each step and their potential for increasing the current circularity. Each idea was noted down in relation to its position and the session ended with a decision on which compelling change to go forward with.

4.6.Limitations of the research study

The limitations of this research study is mainly related to the use of a thought-up compelling change that we use to elicit barriers. First, the method only allows us to identify barriers that are related to the compelling change. Barriers, however important they might be, that are not inhibiting the selected compelling change from implementations might not be recognised at all by this study. Also, as the change is hypothetical, we cannot be sure that the barriers found are the same that a real change would be inhibited by. This risk has been mitigated by creating the change together with the companies, in order for it to be as close to their operations as possible, and thereby easy to appraise and evaluate for people within the respective organisation. Still, would the company seek to actually implement the change, it is possible that other barriers would be found.

The ability to make generalisations from this study can be considered to be quite low. As the studied companies are different, the ability to compare findings between the two cases in order to verify them is limited, which makes it difficult for us to conclude to which degree our findings are general. Instead, this study contributes by offering a rich picture of the studied barriers.

The method used to identify and describe barriers in this study will also have limited ability to understand their respective importance and relationships. This is an important area for obtaining a full understanding of what is inhibiting companies from adopting circular initiatives.

4.7. Data collection

The data collection was carried out in two stages. The first stage was of exploratory nature in order to understand the field of study and to give a basic understanding of the organisations. The interview in this initial stage were conducted before the literature review and were used to formulate the project plan. The second stage was of an investigative nature and used the findings from the literature to probe for their occurrence at each partnering company.

4.7.1. Interview guide

The questions in the interview guides were based on the barriers from the literature study. The interview guides were constructed with open ended questions and to allow for clarifying questions and probing. Edmondson and McManus (2007) support this approach when claiming that interesting ideas and concepts emerge and should be pursued with subsequent interview questions. By using this approach, they argue that new insight and theory is allowed to take shape throughout the interview. The interviews were structured around the compelling change, with the goal of finding out, from the perspective of each interviewee, if the compelling change were to take place, what would be needed?

4.7.2. Sampling

Initial interviews were conducted with the contact person at each company. The result of this interview, along with the result from the workshop was then used to formulate the compelling changes that serve as the tool to allow us to investigate the organisational barriers for circularity. The compelling changes were then shared with the contact person at each company which then provided the contact information to other people within the organisation who they thought knew more about the field. This initiated a snowball sampling of respondents (Easterby-Smith et al., 2015) and each new person was asked, after they had been interviewed, to recommend other individuals with insight surrounding the compelling change. The snowball method of finding respondents was chosen as it is appropriate when access is difficult (Easterby-Smith et al., 2015) as with the case of VCC. At HRB, being a much smaller company, we interviewed everyone with a strategic role in the company. We asked several of the respondents the same question as a way to ensure validity in our findings. By bringing in the perspective of different viewpoints within the same organisation we were able to achieve a form of triangulation.

4.7.3. Interview setting

All interviews in the second investigative stage were recorded for transcription. Each respondent had the opportunity to abstain from the recording but no one did. Some interviews were conducted via phone but we aimed at doing as many as possible in person. Every interview was done in pairs where one person was designated as interviewer while the other took notes and asked clarifying questions. Selective transcriptions of each interview was done by listening through the interviews one more time and noted down the crucial pieces of information. In total, we conducted 17 interviews with 14 people at the two companies (see table 11 and 12).

VCC		
Role/person	**Department**	**Length**
Remanufacturing manager	Aftermarket, remanufacturing	2 h + 1h
Senior strategic environmental advisor	Environmental department	30 min
Product manager, spare parts Sweden	Volvo Cars Sweden	1 h
Requirements engineering expert, Environment	Environmental department	1,5 h + 20 min
Project manager	Project management office	1 h
Commercial project leader	Project management office	1 h
Remanufacturing engineer	Aftermarket, remanufacturing	1h
Requirements engineering expert, Serviceability	Aftermarket	1h
Previous business manager, remanufacturing	Aftermarket, remanufacturing	30 min

Table 11: List of interviews VCC

Role/person	Length
Marketing manager	2x 1 h
CEO	1 h
Financial Assistant	1 h
Production and Planning manager	1 h
Sales manager	1 h

Table 12: List of interviews HRB

4.8. Data analysis

The data from the interviews were coded against the barriers from the literature study. In practise this meant that we listened through each recording from the interviews and paused at each statement the respondent made about any difficulties and challenges they have experienced or heard about. The statements were listed and one by one labeled with an area, e.g. reversed supply chains. The statements making up the data for each area were then analysed together and connected to one or several barriers. Those areas not belonging to any previous found barrier was categorised as new.

The data analysis is often the part of a study most exposed to validity concerns. Since validity refers to the causal relationship between variables and results it is an important criteria to assess the rigor of the study (Gibbert 2008). To ensure this, conclusions are drawn based on data from several different sources. To further strengthen the validity of the study and to comply with the discretion regarding the data collected, each company was given the opportunity to review a draft of the report towards the end of the project. This was done partly so that they could pick up on any misunderstandings or incorrect interpretations made by us, but also so that no sensitive information would be revealed. In this process only minor changes were made that improved the accuracy of the end results. The changes made were mostly clarifications and corrections aimed to shed more light on certain aspects of an issue.

5. Results

The following section will present the empirical findings from the data collection made at each company. Each subsection starts with an explanation of the compelling change, followed by a description of the current situation. This is then followed by the findings.

5.1. VCC

5.1.1. Compelling change

The compelling change at VCC focused on the remanufacturing department's role in the requirements engineering process. The requirements process was identified as a key to increased remanufacturing. In the process followed today, remanufacturing is used as a means for the aftermarket to provide spare parts over an extended period of time. There are however other benefits to remanufacturing that are not taken into consideration in today's model. One of those is the positive effects of remanufacturing on the environment. Environmental impact is a requirements category at VCC today so the compelling change generated in the workshop was to let remanufacturing be a specifier for that category of requirements instead.

5.1.2. Current situation before compelling change

Requirements engineering at VCC is organised according to the V-model (Maurer and Winner, 2013). In the model, abstract high-level requirements on the product category are linked to specific requirements for the product, which in turn is linked to component-level requirements and specifications (Maurer and Winner, 2013). Each level of requirements and specifications corresponds to an opposing side of tests that are used to verify that requirements are being met. The requirements engineering process starts with high-level business goals for the project and ends with detailed requirements and designs for each component of the vehicle, specifying every characteristic of the new car.

Each new car project and updates to an existing car are organised into a programme. The programme is organised in a stage-gate model and requirements at different levels of the V-model are set at the different gates of the product development model. Within each programme there are a number of representatives for different attributes of the car. These requirements engineering experts are responsible for putting forward requirements on the vehicle relating to their individual attribute. These attributes, around 30 in total, includes fuel economy, ergonomics, safety, aerodynamics, and environmental impact.

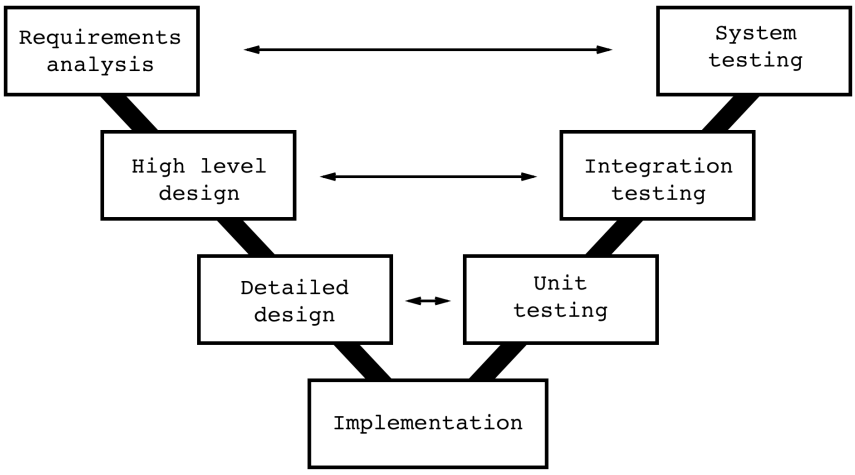

Figure 6: The V-model adapted from Maurer and Winner (2013)

Conflicting requirements are dealt with in an ongoing negotiation process between representatives for different attributes, constructing engineers and project managers. Different requirements are often intertwined and affect several departments and attributes at once. An example of such relationship is expressed by the interviewed project manager in the quote below. Compromises between requirements are made continuously. The goal is to reach the business targets that have been set up for the project and ultimately to sell cars to consumers. Conflicts between requirements are resolved with these business goals in mind.

"Something that affects the fuel efficiency of the car hugely is the air resistance, how aerodynamic the car is. You can build a car that is super aerodynamic, but then the design department will say 'forget it', or someone from ergonomics will say that it won't work. [...] To weigh input from design, ergonomics, fuel efficiency, and achieve something [...] that is the real challenge"
– Project manager

Requirements regarding the environment are organised and put forward by the environmental department. These include emissions, toxins and air quality, and are referred to as environmental impact.

The activity of remanufacturing is organised by the department for customer service and aftermarket. The department handles the sales and logistics of spare parts and aftermarket products. In the requirements engineering process, global customer service put forward requirements through the attribute called serviceability, which is related to different aspects that make sure that the car will be easy to repair and service once it has entered the market.

5.1.3.Findings related to barriers

In this section, findings from the empirical study at VCC are presented following the structure of the literature study. Due to limitations in the method some barriers were not possible to study. Selecting a specific compelling change for the study has implication on which barriers that the study could observe. Only the barriers that inhibit the compelling change from taking place are the once that will be observable. Therefore, some barriers from the literature study were not encountered in this empirical study. An overview of which barriers that were studied is displayed in table 13.

Barrier	Included in the study	Not included in the study
Reverse supply chains are challenging	X	
Long lead-times and uncertain processing time	X	
Low availability and high cost of replacement parts	X	
Lack of measurability	X	
Lack of life-cycle perspective	X	
Lack of marketing strategy for remanufacturing	X	
Lack of business case	X	
Cannibalisation		X
Presence of counterfeits and secondary markets		X
Unsupportive government and regulation		X
Customer dislike and lack of understanding		X
Absence of advanced remanufacturing technology		X
Lack of expertise	X	

Table 13: studied barriers at VCC

5.1.3.1.Reverse supply chain are challenging

From the literature study: Many companies struggle with the reverse supply chain needed to return used products .

The studied company have experienced challenges with operating its reverse supply chain for remanufactured parts. On the global level, the remanufacturing department monitor and account the returned cores. Focusing on the local market, in our case the Swedish market, it appears to be delays and lack of reporting within the company's logistics system. The effects can be noticed in the scoring system that the company uses to reward workshops that return cores as agreed. The scoring system is supposed to charge workshops that are not returning their cores. However, because of uncertainties in the logistics reporting, VCC are not charging their customers since they may very well have fulfilled their part of the contract. As expressed by the interviewed product manager in the quote below, VCC have not charged any workshops on the Swedish market the past decade.

"The system is not reliable. We can't point at the dealers and say that they haven't returned their stuff. Because there is problems centrally with the handling. [...] We haven't charged any dealer in 10 - 15 years from what I know."
– Product manager, spare parts Sweden

5.1.3.2.Long lead times and uncertain processing time

From the literature study: Generally the lead-time of remanufacturing is high. It is affected by the quality of returned cores which acts as an uncertainty.

There are several uncertainties regarding remanufacturing activities at VCC. Both the demand and the supply of remanufacturing are hard to predict and create certainty around. As illustrated by the quoted remanufacturing engineer below, it is not known beforehand how big the demand of a remanufactured component will be, as this is dependent on to which extent the original component is worn down and breaks. The amount of components that the remanufacturing process is able to supply is dependent on the quality of the returned cores. The wear on the component during its use phase is not in the hands of the company to control, and some of the returned cores are not fit for remanufacturing. As explained by the remanufacturing manager quoted further down, the quality of the core is sometimes not known until the start of the remanufacturing process. Together, these factors makes remanufacturing more uncertain compared to regular production.

"This engine we talked about, it can go through all the logistics and reach the renovator before it is revealed that it is just scrap [...] It's where this differs from production, it is more speculative"
– Remanufacturing manager

"So we need to find a product that is of bad quality. One that is switched often. That is a good product for us. And you don't know that beforehand, where issues with quality will appear. Because if you knew that, you would have done things differently."
– Remanufacturing engineer

5.1.3.3.Low availability and high cost of replacement parts

From the literature study: low availability of replacement parts make remanufacturing difficult.

Securing availability of replacement parts is a challenge for the remanufacturing process at VCC. This is partly due to the fact that parts are procured as entire systems, which is beneficial for new production, but challenging for remanufacturing. During new production, a part can be procured as a whole unit, where several small components and parts are treated as an entire system, for instance a disc brake. In the remanufacturing process, the system is broken down into its components, as some of the springs or pads of the disc brake will need to be replaced. The interviewed requirements engineering expert stressed the importance of individually contracting and registering the sub-parts that constitutes the procured system, which is illustrated in the quotes below. If not, low availability is a risk. Today, contracts with suppliers regards the system, and not the availability of its parts for future remanufacturing, which makes securing availability difficult.

"After eight years, where are those parts? Are we going to produce new ones? That will be crazy expensive"
– Requirements engineering expert, Serviceability

"We want all ingoing components registered as spare parts. But not today. We want it in a while, when we start our remanufacturing.
– Requirements engineering expert, Serviceability

Another challenge regarding parts availability is price increases after the end of new production. As the requirements engineering expert explained which is quoted below, contracts for procurement have different prices for the supply of whole systems to new production and for the supply of parts to the aftermarket later on. As the volumes become lower, and the supplier moves on to other new projects, the price of the parts required for the remanufacturing process increases. This affects the profitability of remanufacturing activities.

"They commit, and say sure! And we'll have a purchase price of 10 SEK. And then when we want them available for 15 years, they say 'no problem! that'll be 200 SEK a piece' That is a difficulty"
– Requirements engineering expert, Serviceability

However, the availability of parts have improved over the last years due to the transition towards platforms. Previously, cars were produced individually in seven-year cycles. Today, platforms span over a 15 year period, which makes it easier to secure the availability of parts needed for the remanufacturing process.

5.1.3.4.Lack of measurability

From the literature study: several authors state that it is difficult to measure remanufacturing in terms of quality, economics and environmental impact.

Several interviewees stressed the importance of being able to measure or quantify an initiative for it to be accepted into the requirements process, which is quoted below. The interviewees mentioned both measurement in economic and environmental terms. Quantified measurements of quality were not mentioned in any interview.

Measuring is important for the company in relation to laws and regulations, and in the communication towards customers, independent testing institutes and also within the organisation. The way that the company's products are evaluated by media, institutes and customers translates into requirements and prioritisation in the requirements engineering process, according to the interviewed project manager. Further, some measurements are regulated by law so that they have to be communicated in marketing materials, others are constructed by independent institutes that test all vehicles according to a standardised procedure. These tests and measurements are also important in communication towards customers and are to a large extent what drives competition within the industry.

"All cars that are sold in Europe are tested in the exact same way [...] so we have to certify the cars and we have to communicate those numbers [...] They need to be made visual when selling the car"
– Project manager

"[Regarding what VCC is measured on externally] and it is these things that first and foremost are used internally for requirements setting - these are concrete things that one can use for requirements"
– Project manager

Similar difficulties measuring performance have appeared before in the organisation. Previously, initiatives regarding design for recycling were tried but were abandoned due to difficulties in showing any evident benefit. The aim of the initiative was to introduce requirements into projects regarding the possibility to disassemble the car after use; that way making recycling easier and cheaper. However as explained by the requirements engineering expert for environmental requirements in the quote below, it was both difficult to assess the environmental benefit of the initiative, and find a way to justify the cost increase from the perspective of the customer. Because of this, the initiative was abandoned.

"[Regarding Design for Recycling] we never really reached any results, because there was no value for the customer whatsoever [...] there was some sort of environmental benefit, and it was pretty difficult to quantify"
– Requirements engineering expert, Environment

5.1.3.5.Lack of life-cycle perspective

From the literature study: Research shows that many companies have a short-sighted perspective, and a mass-production mentality that inhibits remanufacturing and promotes products with a short lifespan.

Current ways of measuring environmental impact and calculating costs fail to incorporate the effects of remanufacturing. According to an interviewed environmental advisor and a previous business manager for remanufacturing which are both quoted below, this is due to a focus on per-item purchase price and the total production costs per car, which are ways of calculating that fail to encapsulate the costs and profits of remanufacturing. As remanufacturing activities takes place several years after the car has been produced, its profits are not visible or considered sufficiently during the new product development. Similarly, the measurements of environmental impact that the company uses are constituted by emissions in productions, tailpipe-emissions and the ability for end-of-life recycling of the vehicle. These measurements do not take remanufacturing activities and its associated environmental benefits into account.

"Generally, we are not good at life-cycle cost on cars. There is a lot of focus on the cost of specific items"
– Senior strategic environmental advisor

"For remanufacturing to increase you need to total cost perspective on the entire life-cycle of the car [...] you don't have that today"
– Previous business manager, remanufacturing

5.1.3.6.Lack of a marketing strategy for remanufacturing

From the literature study: Researchers claim that the absence of a marketing strategy for remanufacturing results in low knowledge and demand of remanufactured products consequently leading to a loss of potential profit

Marketing of environmental initiatives is only done with caution at VCC. As the marketing department works with identifying the values, needs and desires of specific target groups, and finding ways to position the company's brand in alignment with those, there is little room to push other messages

within the same channels. The interviewed commercial project leader who is quoted below, had experience of green marketing initiatives, stressed the importance of financial aspects for the customers and that communication regarding the environment usually is difficult to capitalise on.

"The difficult thing with the environment is that it is difficult to sell. [...] It is often the financial that governs"
– Commercial project leader

It is important for the company to remain focused in its communication with the customer. To do this, messages that are created must fit the intended recipient, and it must also be presented in a way that is interesting. As the commercial project leader further explained in the following quote, communication that is uninteresting or not aligned with other messages can damage the brand and lower the efficiency of the marketing efforts.

"You don't want to become a boring brand [...] If you talk about things that the customers aren't interested in, they don't want to hear that, so you need to tweak it. Like safety, 'boring safety'. People don't want to hear about the amount of people that die in traffic. You need to make it more innovative, high tech. Not safety, ACTIVE safety. That way safety is fun"
– Commercial project leader

Remanufacturing is considered to be uninteresting and of low importance for the customer, according to a product manager working with spare parts which is quoted below and other stakeholders within the organisation. Also, remanufacturing activities have little to no impact on the first customer that buys the car new, which was highlighted by a requirements engineering expert in the subsequent quote. Rather, it is the second or third owner that can benefit from remanufacturing. In addition, the fact that parts are remanufactured are often unknown to the end customer. These factors make remanufacturing difficult to market, and of low importance for the marketing department.

*"Customers doesn't give a s*** about replacement parts. As long as they get their car repaired.*
– Product manager, spare parts Sweden

"It is not of value for the customer who is buying the car. It really favours the one that owns the car when it breaks down"
– Requirements engineering expert, Environment

5.1.3.7.Lack of business case

From the literature study: It is difficult to analyse remanufacturing business cases due to there being a lack of model, and also because of uncertainties in demand and input material.

When asked about what is needed to motivate the introduction of new requirements, several interviewees mentioned the importance of a viable business case. Introductions of new requirements are usually motivated by reduction of costs, increase of sales, a possibility to charge a higher price or as a reaction to new or anticipated law and regulations. Requirements regarding the environment are in most cases introduced with a regulatory motivation, which is illustrated by the quoted project manager below. Business cases regarding environmental initiatives are usually related to communication and marketing towards a certain market segment.

"I know that most of it [environmental requirements] are sprung from a regulatory procedure or a standard"
– Project manager

Several interviewees stressed the importance of being able to quantify a business case. In order for a business case to succeed a motivation in numbers is needed. Interviewees mentioned both that the initiative should be motivated in economic terms, i.e. how much the potential business impact would be, and also in terms of environmental savings.

5.1.3.8.Lack of expertise

From the literature study: As remanufacturing activities sometimes takes place long after the end of production, people with knowledge about the product may not be around. Also, it can be difficult to find people with the diverse set of skills that are needed for remanufacturing.

Remanufacturing activities at VCC starts long after end of production of new parts. First, VCC activates the collection of used cores through it network of workshop around the world to a central warehouse. Once cores have been collected, and there is a demand for remanufactured spare parts, remanufacturing activities are commenced. As VCC procures almost all parts from suppliers, the remanufacturing takes place at remanufacturers contracted by the supplier.

When planning to initialise remanufacturing along with a supplier, lack of experience is sometimes an issue. The interviewed requirements engineering expert explained that since a long time has passed since the development of the part, the supplying

company may lack detailed know-how regarding how to best remanufacture the part. This is illustrated by the following quote.

"If it's something that was made eight years ago, well you can think how fun that is. They hardly know what it is. To then make them commit to remanufacturing. That is a difficulty.".
– Requirements engineering expert, Serviceability

5.1.4.Other findings

Since we adopted an exploratory method for this study, we used open ended questions to each respondent, probing for barriers not mentioned in the literature review. The results from these questions are in the following section.

5.1.4.1.Split competencies within the organisation

The expertise on requirements differ between the departments. When discussing the expertise needed to introduce environmental requirements related to remanufacturing several interviewees concluded that the knowledge currently is split between the different departments. The environmental department possesses knowledge and experience relating to environmental requirements, mainly regarding different types of emissions and hazardous materials. The department for customer service and aftermarket have experience in formulating requirements related to cost and efficiency of aftermarket activities, for example ensuring that the cost and durability of replacement parts create an attractive aftermarket business.

When asked about this, the interviewed environmental advisor acknowledged that there was a gap in knowledge between the departments. This is illustrated by the quote below. More specifically, the advisor explained that the remanufacturing department does not hold the expertise to formulate environmental requirements.

"I don't feel that it is the right thing that they [the remanufacturing department] should build up the competency around this [environmental requirements for remanufacturing]
– Senior strategic environmental advisor

Remanufacturing is currently not putting forward requirements from an environmental perspective. Little communication is taking place between the group working with remanufacturing, and the department working with environmental requirements. Interviews with remanufacturing engineers show that there is a perception of not being able to put forward requirements into new projects as wished, this is illustrated by the quote below. The interview with the environmental advisor, displayed in the subsequent quote, displays that the difference in competencies in the different departments affects the nature of the requirements, and that the involvement of the environmental department would increase the chances for environmental remanufacturing requirements.

"When we become involved everything [design of new components] is already set. It is no longer possible to influence it."
– Remanufacturing engineer

"If serviceability would have it [responsibility for remanufacturing requirements] there would be more of a cost focus. But if it goes through environmental impact there would be another meaning to it"
– Senior strategic environmental advisor

5.1.4.2.Procurements hampers remanufacturing

Most components used by VCC are procured from suppliers. Often, systems of several components that together deliver a function are bought from the same supplier. In this way, VCC has only to specify system level requirements, such as the performance output from that system. The supplier is then responsible for the detailed design of the included components. The main component that is not procured, but designed and produced in-house entirely is the engine.

Outsourced design activities impede the communication between the remanufacturing group and the designing engineer, according to engineers in the remanufacturing group. Engineering experts in the remanufacturing group have the wish to bring forward specific component-level requirements to the responsible design engineer in order to adapt the component for future remanufacturing. For the interviewed remanufacturing engineer quoted below, it was obvious that in-house design and R&D benefited collaboration.

"Naturally, it is easier to have influence on products that we build by ourselves [...] For example that it is possible to grind a crankshaft, that the hardening depth is deep enough. We have some purchased products were if you grind the crankshaft you grind away the hardening, and that is not good. Then you need new crankshafts, and then the business opportunity [for remanufacturing] disappears"
– Remanufacturing engineer

Procurement from big suppliers makes it difficult for VCC to change specific requirements. As the suppliers produce large quantities of similar components on one production line that have only small design alterations per customer, changes are difficult and expensive for VCC. The system level

procurement of components transfers the design activity to the supplier, making detailed requirements changes for remanufacturing more difficult to implement.

Also, suppliers may not be interested in remanufacturing activities. The focus of many suppliers is on producing and selling new components, and not on the collection and remanufacturing of old ones. Some of the suppliers lack processes for remanufacturing and prefers large-scale new production. This is, according to the requirements engineering expert on serviceability which is quoted below, related to the fact that remanufacturing is an activity that takes place long after the end of production, where suppliers have to handle components that they stopped producing years ago. Suppliers then deal with remanufacturing in an ad-hoc way.

"When the suppliers move on in their development, they aren't even producing that part anymore. So they'll have to tinker with it on a bench somewhere."
– Requirements engineering expert, Serviceability

5.2.HRB

5.2.1.Compelling change

The compelling change studied at HRB was a change in the way that the company exchanges their customers' mats. Instead of changing them on a regular interval, the intention was to change them only when needed. This new model corresponds to what is defined as activity management in Tukker's classification of PSS models (Tukker, 2004). By changing the mats when needed, HRB can achieve a higher utilisation of each mat before it is taken in for washing. In effect it means that clean mats are allowed to stay longer in service while the dirty mats will be changed sooner. The revenue stream from this functional sales model would be ensured by a subscription based service where the offer is a clean mat for a set monthly price. At the same time, this activity management model creates a potential upside for HRB to perform their changes in the most cost effective way. The washing process has been identified as what is limiting the lifetime of the mats and therefore the increased circularity of this compelling change comes from fewer required washes of each mat.

5.2.2.Current offering and operations before compelling change

The sales process is usually initiated by following up on a lead. The leads are usually generated through either a marketing campaign or direct contact. The salesperson then travels to the customer's facility and performs a needs assessment as a part of the sales process. The needs assessment is based on type of entrance, type of material on the ground outside (paved or gravel etc), number of expected entrants per day and how clean the facilities need to be. This information is used as input as the salesman then puts together an offering for that specific customer. The result includes a suggestion of a type of mat, what interval it needs to be changed and a price. The number of actual entrants and the weather are factors that always vary, yet the mats are changed on a regular basis. To address this need the customer has the opportunity to at any time change the frequency of the regular changes. It is common that customers request an increase in frequency during fall and winter.

The changing cycle at HRB starts with the drivers leaving the washing facility with a van full of clean mats all designated for each customer on the route. Arriving at each location he carries a mat with him in and takes the old one with him back to the van. He is instructed to give a cheerful impression and be open to any interaction with the customer. Coming back to the washing facility the dirty mats are all washed dried and sorted after size, type and colour waiting to go out again. Taking mats from the storage, the sorters then pack each mat according the route planning found in a binder making them ready for next pickup by the drivers and the cycle is complete. HRB tries to maximize either customers per area or mats per customers to get the most yield from each driver. Changing one mat per customer over a large area is not profitable.

5.2.3.Findings related to barriers

In the following section we describe the findings made at HRB following the structure of the literature study.

Due to limitations in the method some barriers were not studied. Selecting a specific compelling change for the study has implication on which barriers that the study will be able to observe. Only the barriers that inhibit the compelling change from taking place are the once that will be observable. Therefore, some barriers from the literature study were not encountered in this empirical study. An overview of which barriers that were studied and which were not is displayed in table 14.

Barrier	Included in the study	Not included in the study
Conflicting interests in the value chain	X	
Unsupportive regulatory framework		X
Increased operational complexity	X	
Product-service systems are difficult to measure	X	
Customers prefer owning products		X
Insufficient trust and privacy	X	
Product-service systems require a big organisational change		X
New skills and knowledge required		X

Table 14: An overview of the barriers studied for HRB

5.2.3.1.Conflicting interests in the value chain

From the literature study: members of a value chain may have conflicting interests detrimental for the PSS.

HRB uses one supplier for most of their mats. When addressing the relation to this supplier we wanted to find out if they experienced any concerns regarding the quality and lifetime of the mats that would indicate that the supplier's interest was not in line with those of HRB. They reported no such concerns and explained that they have a continuous dialogue with the supplier regarding the state of their mats and that the supplier is keen on knowing the results from HRBs own testing of samples. This is illustrated by the quote below where the production manager discusses the feedback that HRB gives to their suppliers.

"[regarding a common interest for durable mats] I don't know but I count on it. They always get our feedback on how long the mats lasts."
– Production manager

HRB reported that there is virtually nothing that keeps them to that specific supplier. This came up in a discussion regarding what would happen if they feel that their interest are not in line with the supplier. There are around five possible suppliers that all have a similar offer. Although many of them also produce mats made for sale the product lines are specifically developed for washing and directed towards companies like HRB and those operating a similar business model. As illustrated in the quote below from the production manager, HRB have the knowledge and capability to evaluate products' performance and durability. They can easily switch supplier as they chose.

"I don't see any problem for us to change suppliers if that would come up. We try new mats in our own facilities all the time. "
– Production manager

5.2.3.2.Increased operational complexity

From the literature study: managing the product after point of sale leads to an increased operational complexity.

When presented with the compelling change the production manager stressed the importance of unchanged revenue streams. Following this he then highlighted issues concerning uncertainties in the delivery routes that the need based changes would lead to, as illustrated in the quote below. It would, according to the production manager, complicate the set routines of today that allows for an even flow, both for the drivers but also in the process of washing, drying and storing the mats.

"You would not know what to deliver and when at first. There is already today a lot of hinders and far to drive. If we are going to Halmstad one day of the week then I want to take all"
– Production manager

The sales manager and the marketing manager shared the picture given by the production manager, namely that the need based changes would affect the operations and logistics negatively. This is illustrated by the two subsequent quotes. As today's business is managed by a clear schedule where everyone can expect what will happen in each week the functional result model would stir the operations. It was also mentioned that the change would make it complicated for the drivers to know where they would be going and who to talk to. Today they all have designated customers and routes where they each find their way best and over time some have even built a relation with the customer.

"It would be difficult for us internally. Both logistically and with the planning.

What we are trying to achieve is an even change frequency."
– Sales manager

"Nobody knows the customer as well as the driver."
– Marketing manager

The sales manager and the financial assistant mentioned that this would lead to more complex staffing, fluctuating demand on the washing process, and a need for a larger stock that would be underutilized at times. These points are illustrated in the two quotes below. They reasoned that without a predictable flow they could end up in a situation when there is no need for any mats to be washed and the production and staff is underutilized whereas at another point they could have too much to do and machines and staff would not be enough.

"It would be another way of thinking. It will be very demanding for our operations with planning. I know right now how many customers we have and with agreements that allow us to see what staffing we should have. What resources we need to manage our operations."
– Financial assistant

"We have a certain number of mats in circulation. There are mats out with the customer and there are mats that are in for washing. And if customers are going to have a more frequent change in winter, then we have to buy more mats that we will have in stock in the spring and summer instead."
– Sales manager

5.2.3.3.Product-service systems are difficult to measure

From the literature study: A PSS is difficult to measure and therefore becomes hard to market within the organisation as well as communicating the benefit to customers

It was not seen as difficult to assess the potential of the new PSS business model from a measuring point of view. The KPIs used by HRB today, such as mats changed per kilometer or number of mats per car, were believed to be suitable also in the new type of PSS. In addition the production manager said that he did not think it would make anything different as long as the revenue stream stayed the same.

"I don't really care if the car then suddenly is half empty, as long as the money coming in is the same."
– Production manager

In contrast, approaching the customers with the PSS, the respondents stated that it will likely require some form of quantifiable argument to persuade them of the value. The change in pricing must, according to the sales manager who is quoted below, be followed by a clear and understandable motivation. The customer can easily grasp the week intervall setup that is used today and the abstract concept of a clean mat was something the respondents saw as an obstacle. The environmental gain could easily be calculated by showing the reduced number of rides required according to the product manager. However the actual value gained by the customer can not so easily be captured in any metric.

"It all comes down to that we must motivate why we charge a certain price without knowing how many times we will visit them. "
– Sales manager

5.2.3.4.Insufficient trust and privacy

From the literature study: Closer interaction lead to less privacy for the customer and expanding the service offer requires more trust from the customer

The respondents gave a shared view of how the change might affect the trust and privacy concerns of the customer. All of them argued that today's solution is marketed as a problem free solution and that the need based changes would lead to new issues in the relation with the customer. There were no indications from HRB that customers would oppose the activity management model based on privacy reasons. The additional information needed from the customers to implement a functional sales model could for instance include monitoring the use patterns of the entrance mats at the customer's location. This information would according to the respondents not be intrusive enough for the customer to raise concerns. The respondents rather pointed towards issues with gaining the trust of the customer concerning the result. They wondered how the customer would react if they were to offer an abstract result, such as a clean mat. The sales manager and the financial assistant both raised concerns on how to communicate the new model to the customer to gain the trust of the customer which is illustrated by the quotes below.

"It will be problematic if the customer thinks that we never change the mats."
– Financial assistant

"It would have been more difficult to explain for the customer."
– Sales manager

6. Discussion

In the following section we will discuss the findings and connect them to the literature study. The section is structured in accordance with the observed barriers.

6.1. VCC

6.1.1. Reverse supply chains are challenging

The findings of the study confirm that reverse supply chains are challenging for the studied company as well. However, not all underlying reasons listed in the literature have been observed. Customers seem not to have an issue or lack of motivation to return cores, unlike what is claimed by Ghoreishi (2011). The reason for this discrepancy is unknown, but it might due to the B2B nature of the relationship between VCC and the workshop that is responsible for the return of the part. The product-turned-core is also of little value for a customer.

Also, no information about cores being sold to secondary markets have been found. Though, these lack of findings may depend on the studied market in Sweden. Other markets may well see these issues, and this study can therefore not conclude anything on the topic other than the fact that reverse supply chains are challenging even for companies with 60 years of remanufacturing experience.

6.1.2. Long lead times and uncertain processing time

There are several uncertainties related to remanufacturing according to the authors in the literature study. The amount of returned cores, the quality of those cores and how many that are candidates for remanufacturing are some of the mentioned uncertainties by authors in the literature search (Mukherjee and Mondal, 2008; Amezquita et al., 1995; Guide 2000). Also there is uncertainty in the demand for the remanufactured component, as described by Ijomah et al. (2007), and Choudhary et al. (2011). The empirical study confirm these uncertainties. As remanufacturing activities have been taking place at VCC for several decades, these uncertainties have all been identified and acknowledged by the company.

6.1.3. Low availability and high cost of replacement parts

The lack of availability of parts that are needed for the remanufacturing process constitutes a challenge at the studied company. This is in line with the findings in the literature study (Hammond et al., 1998). There are, however, some differences between the challenges that VCC faces today and what is claimed by Hammond et al. (1998).

While Hammond et al. (1998), state that the main reasons behind the low availability of parts is product proliferation: the increase in product diversity, the development of the automotive industry have been another. During the last years, the move towards platforms has decreased the amount of unique components per car model and increased the average life-length of each part, thus enabling increased remanufacturing. This discrepancy between literature and case study may be explained by the development that the automotive industry has seen during the two decades since the article was published.

Instead, system-level procurement creates challenges with parts availability for remanufacturing. Due to underspecified contracts, some detailed components needed for remanufacturing are not secured in terms of availability and are therefore challenging to obtain or expensive once remanufacturing is about to commence. While system-level procurement is beneficial for new production as it leads to lower costs, it also creates cost increases for remanufacturing. As the cost of parts that are needed for the remanufacturing process increases, the business opportunity might be lost.

6.1.4. Lack of measurability

Several authors from the literature study state that a barrier inhibiting remanufacturing is the lack of information regarding the environmental benefit and resource savings that remanufacturing leads to (Subramoniam, 2009; Saavedra et al., 2013; Zhu et al., 2014). These claims are confirmed by this study. Interviewees at VCC support Zhu et al. (2014), and Subramoniam (2009), in that available information for customers regarding the benefits of remanufacturing is important. However, there are risks associated with communication of remanufacturing. These are elaborated on in the later section regarding lack of a marketing strategy for remanufacturing. Further, the importance of data available as a support for the internal decision making process mentioned by Saavedra et al. (2013) is also

confirmed. Naturally, decisions cannot easily be taken in favour of an initiative that has unknown benefits.

6.1.5.Lack of life-cycle perspective

Ijomah et al. (2007) state that companies have a short-sighted perspective and lack a life-cycle thinking when dealing with remanufacturing. This is, according to Ijomah et al. (2007), displayed as companies design products intended for "one life", by using less durable materials, and by not designing for disassembly.

Our findings do not support Ijomah et al.'s (2007) claims directly. The company is aware of how the use of materials of different durability and designing for disassembly can affect the possibility for future remanufacturing. This was noticed during interviews with people working with remanufacturing and requirements engineering. In fact, it is not a clear lack of knowledge in the field of design for remanufacturing that is the company's inhibiting factor. Rather, it is arguments for the benefits of design for remanufacturing that the company is not able to formulate. While Ijomah et al. (2007) acknowledge that "designing for disassembly is costlier", they fail to present a motivation for why a for-profit company should seek to make their products easier to disassemble. A discrepancy exists between what information and data regarding remanufacturing benefits that the company can produce, and what is needed for a requirements change to actually take place.

To provide this motivation that can support design for remanufacturing, a life-cycle perspective is needed in the way that the company accounts for costs and environmental impact. The current way that these are accounted for acts as a barrier for increased remanufacturing activity. Decisions regarding costs have a focus on per-item production costs according to several interviewees, and therefore fail to fully include activities that take place long after production such as remanufacturing. In a similar way, as environmental assessments are based on emissions in production and tailpipe emissions from the vehicle, benefits from remanufacturing such as less need for raw materials or lower energy usage in the production of spare parts are not encapsulated. As the full effects of remanufacturing activities are not taken into account they cannot be considered when specifying requirements and designs or compared against cost increases in production. The lack of a fair assessment of remanufacturing leads to it having lower priority and less negotiating power in the requirements engineering process.

6.1.6.Lack of a marketing strategy for remanufacturing

The difficulties with a marketing strategy as mentioned by Sharma et al. (2016), was not observed in this study. Sharma et al. (2016), cites Östlin et al. (2009), and Majumder and Groenevelt (2001), who elaborates on different scenarios where the lack of marketing strategy is hampering the sales of remanufactured products.

In our study we found no indications that VCC have problem pricing and marketing their remanufactured products. That being said, the problems described by Östlin et al. (2009) and Majumder and Groenevelt (2001) via Sharma et al. (2016) regarding absence of a marketing strategy may very well exist for VCC but this was something that we could not capture with our compelling change method. The research method applied to this study only allows for the study of barriers related to the selected compelling change. As pricing strategies were not, they could not be studied.

What we did observe was VCC's difficulties to promote the remanufactured products from an environmental perspective. The company sees a risk in the marketing of initiatives that are not what customers prefer hearing about. The company must then find a way to make the communication relevant and interesting for their customers. In addition to this, our findings show that VCC believes that marketing remanufacturing would have little impact on those buying a new car. Respondents saw remanufacturing as being of benefit for the second or third owner of the vehicle. Together, these factors highlight that there are very few incentives to actively market remanufacturing. As explained by Östlin et al. (2009), if it is not possible to market remanufactured products, demand tends to be lower.

6.1.7.Lack of business case

It is difficult to assess remanufacturing business cases. This is, according to Subramoniam (2009), because of a lack of analysis models that managers can use to assess remanufacturing business cases. Here, Subramoniam (2009) refers to the decision whether to initiate remanufacturing of a product that is already on the market, and the information that can be used as a decision support while doing so. The difficulty of this assessment have not been examined in this study, and we can therefore not draw any further conclusion regarding it.

However, our findings suggest that the assessment of a remanufacturing business case is needed, and that it should take place, much earlier than mentioned by authors in the literature search. Our results display that remanufacturing activities are

impeded by a lack of early involvement in the new product development process. The decision should we remanufacture this component or not? is very much dependent on the design of the product, and thereby the preceding requirements engineering process. These are activities which take place early on in new product development. This is not brought up by the authors of the literature search, whose focus is on the go-no-go-decision of remanufacturing; a decision that takes place long after product development and production.

Several authors discuss early remanufacturing activities such as design for remanufacturing (Ijomah, 2007; Nasr and Varel, 1997 cited by Subramoniam, 2009), but do not discuss how these costlier design choices can be supported by a early-on business case for remanufacturing. Others discuss the economic justification of whether to remanufacture or not, and also the concept design for remanufacturing, but keep the two topics separated from each other (Thorn and Rogerson, 2002, cited by Subramoniam, 2009). There is a lack of an explanatory model that can motivate design for remanufacturing with regards to profitability.

There is need for a way to make early assessments of the financial potential of remanufacturing. What is missing is a way to weigh the potential benefit of a requirements change against its associated cost increase. This is, however, made difficult by the several uncertainties regarding remanufacturing that was discussed earlier (Mukherjee and Mondal, 2008; Amezquita et al., 1995; Guide 2000). Requirements changes that would enable increased remanufacturing in the future, cannot be supported with facts and figures today, whereby the company instead makes the choice of opting for reductions of production costs that are easier to account for.

Ideally, the the benefits of remanufacturing should be assessed on an aggregated system level. In order for early strategic requirements and goals to be put in place that favour remanufacturing, a high-level system perspective is needed. Keeping a component-level detailed perspective forces remanufacturing to enter the requirements process at a late stage, when the details of each components are being discussed. As this is long after the strategic goals of the project have been set, it leaves little room for design changes that enables more remanufacturing and only small alterations with limited potential can be done.

The lack of clear information inhibits the benefits of remanufacturing from being a factor of comparison among external stakeholders. As claimed by Michaud et al. (2011), the lack of information is a barrier for customer understanding and demand for remanufactured products. In extension to this, our findings show that this also applies to other stakeholders such as media and independent testing institutes. While it is definitely not certain that better information automatically would lead to remanufacturing being of interest for external stakeholders, a lack of data inhibits the possibility almost completely. Without a clear way of assessing and comparing "the degree of remanufacturing" that companies are doing, remanufacturing cannot be a factor for competition between companies. Remanufacturing initiatives can then only be motivated from a cost reduction perspective, and not also from an environmental benefit-perspective or a sales increase-perspective.

6.1.8.Split competencies within the organisation

Our empirical study indicate that there is a split of competencies in the organisation that does not favour remanufacturing. While our findings are indicative, they highlight an area of barriers to a circular economy that has not been mentioned by literature. Requirements related to environmental factors are set by people who have knowledge of environmental aspects, but not remanufacturing. Likewise, requirements related to remanufacturing are set by people who have in-depth technical knowledge about remanufacturing, but not experience in motivating requirements initiatives related to environmental aspects. Unlike other environmental issues, remanufacturing requires knowledge found in both parts of the organisation. Also, remanufacturing does not have its own representative in the requirements negotiations. Dissimilar to other requirements aspects, no one has the sole responsibility to promote remanufacturing during the requirements negotiations.

6.1.9.Procurements hampers remanufacturing

Our empirical study show that procurement complicates design for remanufacturing. This is due to three reasons according to our findings: first, communication is impeded, second, design for remanufacturing is hampered by the suppliers economies of scale, and finally, there is little interest from suppliers to concern themselves with remanufacturing.

The communication between departments necessary for design for remanufacturing is made difficult as components are designed fully by suppliers. Detailed design choices on component-level that affects the possibilities for future remanufacturing are made in collaboration between remanufacturing experts and design engineers. As parts are procured and designed by contract with suppliers, the communication channel needed becomes more difficult to establish. This leads to the remanufacturing

expert having less impact on the design of the component, and the component therefore becomes less suitable for remanufacturing.

Suppliers utilise product standardisation to reach economies of scale in their production. By supplying similar products to several of its customers, a supplier can cut costs effectively. Because of this, making detailed design changes for one of its customers becomes difficult and expensive. Making design alterations to adapt a component for remanufacturing, may require the supplier to set up a separate production line for VCC only, which greatly increases costs and thereby the price for that component. There is a lock-in effect, where VCC needs the commitment of the supplier and its other customers in order to make design alterations that facilitate future remanufacturing.

These challenges for remanufacturing regarding procurement and outsourced design activities is not to be found in the reviewed literature. In fact, the studied articles are not much concerned with procurement and the firm-supplier relationship. This is interesting, as our findings indicate a strong dependency between the relationship and communication with the supplier and the possibilities of design for remanufacturing. While many authors highlight the importance of adapting the product design for remanufacturing (Govindan et al., 2016, Zhang et al., 2011, Chakraborty et al., 2017, Sharma et al., 2016, Zhu et al., 2014, Matsumoto et al., 2016, Mukherjee and Mondal, 2008), they do not include the effects of procurement and outsourced design activities in their research. Our study suggests that this is a highly important area to understand in order for increased remanufacturing, and that the effects of the supplier-firm relationship on remanufacturing should receive more attention in the future.

6.2. HRB

6.2.1. Conflicting interests in the value chain

Vezzoli et al. (2015) state that conflicting interests in the value chain may hinder PSS adoption. Vezzoli et al. (2015) cite Cooper and Evans (2000), who state that manufacturers are torn between supplying durable products to meet their customers' requirements and maintaining high levels of demand in order to continue the same level of production. Producers have an incentive to maintain a high level of production, which may conflict the introduction of a PSS that can fulfil user needs with fewer products by increased utilisation. In turn, Cooper and Evans (2000) cite Thompson and Holt (1997) who investigate consumerism. Thompson and Holt (1997) discuss the creation or generation of consumer desire as a basis for consumerism.

Our findings do not display any conflict of interest between HRB and its suppliers. There does not appear to exist an unwillingness from the suppliers to promote longer-lasting products. Rather, the durability of the product is an important characteristic that HRB measures and suppliers compete on.

The fact that the barrier described by Vezzoli et al. (2015) and Cooper and Evans (2000) is not present in our studied case can be explained by the market conditions in the industry in which HRB's suppliers operate. There are several competitors within the rental-mat industry, and HRB can evaluate the products and switch between them as they chose. HRB can use their own facility to test the durability of the products, and can therefore properly evaluate each product's performance. Also, HRB can alternate between suppliers and chose products from different manufacturers without much switching costs. Due to this competition between the suppliers, each individual actor cannot control and limit the durability and life-length of the products. If one actor tried to do so, HRB could just switch to another supplier. Additionally, HRB's strict evaluation of the products may also be explained by the fact that HRB is a business, and not a end customer. One might argue that B2B relationships are somewhat more rational and that business-customers scrutinise products more thoroughly than end-consumers, or that they chose products on more functional criteria. Certainly, the specific product category also matters. Mats are, as previously mentioned, evaluated on their durability. The desire for new consumption, as described by Thompson and Holt (1997), can therefore be said to not be applicable to this sort of product.

Our case study highlight that the value chain conflict described by Cooper and Evans (2000) not always is present. The incentive from the supplier to maintain a high demand may still be present, and suppliers may not appreciate a decrease in demand due to higher product utilisation. However, due to a healthy market with fair competition, as well as a type of product that is evaluated on durability and performance, the suppliers are unable to control the demand situation. In cases such as the one studied here, the described barrier is not inhibiting PSS adoption.

6.2.2.Increased operational complexity

Ceschin (2013) suggests that companies going through a servitization of their products will experience an increased operational complexity. This increased complexity stems from having to take care of the products after the point of sale and is mainly a barrier for product oriented firms. In our study we found that the compelling change would lead to an increased operational complexity. But because HRB is already operating a PSS business model the reasons will not be those suggested by Ceschin (2013). The respondents gave a collective picture that the increased operational complexity would be associated with increased need to handle fluctuations in the need for mat changes. This would not only require them to have an increased inventory, but also a more complicated staffing and a dynamic complex route planning. This barrier is confirmed but in another way than it is suggested in the literature review.

6.2.3.Product-service systems are difficult to measure

It seems like HRB is not facing the same kind of measurability problems as those listed in the literature study. Several authors discuss measurability as a barrier for the transition from products sales to PSS. As HRB already offers a PSS, these servitization barriers are not applicable. For example, both White et al. (1999) and Vezzoli et al. (2015) state that a company's existing KPIs may be ill-suited for a PSS offer. But the KPIs used by HRB would be applicable also after a transition to a functional result model. Further, the environmental benefits is also quantified by HRB who keep track of the number of kilometers traveled by car, and the number of washes per customer.

In addition, Coreynen et al. (2016) state that companies struggle to market the benefits of a new PSS offer within the organisation due to a lack of measurability. This was not observed in the case of HRB. The reason for this may be that a founder-owner driven company like HRB is not forced to base business decisions by a measurable impact of the change. When in a large company major projects must be presented in detail before a board of directors, with for instance a cost benefit analysis, a smaller company like HRB can be more driven by intrinsic values when making decisions with a large impact on the business. Examples to prove this statement are found at HRB regarding their investments in environmental friendly technology, such as biogas powered cars and rainwater collection. Investments such as these are motivated by the values of the company more than a strict profit seeking logic based on measurability. It appears as they are not driven by measurable results in the same way as large enterprises whereby the difficulties stated by Coreynen et al. (2016) is not relevant for a company like HRB.

The only measurability issue acknowledged by the respondents relating was how to communicate the new kind of offer to the customer. This is in line with the difficulties of appraising the cost and benefit of a service stated by White et al. (1999) (cited by Vezzoli et al., 2015). Although still not a true comparison between a product and a service our empirical results indicate that it would be hard for HRB to motivate the price they charge if the customer has no practical way of judging if they are getting what they pay for.

6.2.4.Lack of trust and privacy

For the need based changed to function a closer interaction with the customer would be required to assess the state of the mat. In our study there were no indications that this closer interaction would lead to increased privacy concerns from the customer as Mont (2004) (cited by Vezzoli et al., 2015) suggested. Although no customers were surveyed for this study the respondents gave a clear picture that the information required to operate the need based changes model would not be intrusive enough for the customer to raise concerns. One reason for this could be that customers do not regard the use patterns of their entrances as sensitive information.

Tukker (2004) suggests a taxonomy for different PSS offerings spanning from product centered offers to service centered offers. HRB's current offer resembles the products pooling type with much focus on the service. Product pooling means that the product is owned by the provider who is also responsible for all of the associated activities. Following this taxonomy the compelling change means that HRB would go from a product pooling type to activity management for the customers. The activity management type focuses on result rather than use for the customer which relates to the compelling change. Promising a result is therefore more abstract for the customer, and more difficult to monitor. This issue was recognized by the respondents at HRB. Having the mat cleaned on a regular interval is easy to monitor but assessing the cleanliness of the mat is more difficult. They showed concern about how to communicate this new model to the customer and how to motivate the price. This finding is in line with the barrier presented by (UNEP, 2002, via Vezzoli et al., 2015) that if the customer experience reduced control it will hamper the PSS relationship. Our interpretation of this barrier is that the pain associated with the uncertainty of not

knowing if the service is provided or not may be greater than the gain of having the result delivered.

Associated with this barrier we also found that HRB anticipated that the customer would quickly understand the shift in incentive that the need based changes would lead to. If HRB offers a clean mat it is in their interest to do so at the least costly way possible. For example the drive to the customer and the exchange becomes what Tukker (2004) referred to as cost drivers. HRB were concerned that this insight by the customer would be detrimental for the relationship and that the customer would need to trust HRB to carry the service correctly. This issue relates to that said above that the customer also has less control because the agreement on result is on a more abstract level.

6.3. Summary

In summary, the two case studies that have been presented have confirmed 11 barriers from the previously conducted literature study. Out of these, 4 have been extended with additional findings. In addition, we have found 2 new barriers that were not mentioned in the studied literature. For an overview, see table 15.

Area	Category	Barrier
Remanufacturing	Production barriers	Reverse supply chains are challenging
	Long lead times and uncertain processing time	Low availability and high cost of replacement parts
	Business barriers	Lack of measurability
	Lack of life-cycle perspective	Lack of marketing strategy for remanufacturing
	Lack of business case	Cannibalisation
	Stakeholder barriers	Presence of counterfeits and secondary markets
	Unsupportive government and regulation	Customer dislike and lack of understanding
	Technical barriers	Absence of advanced remanufacturing technology
Product-service systems	Lack of expertise	Barriers related to network of stakeholders
	Conflicting interests in the value chain	Unsupportive regulatory framework
	Barriers related to products and services	Increased operational complexity
	Barriers related to the offer	Product service systems are difficult to measure
	Barriers related to customers	Customers prefer owning products
	Insufficient trust and privacy	Barriers related to organisation
	Product-service systems require a big organisational change	New skills and knowledge required

Table 15: The outcome of the study

7. Conclusions

We initiated this inquiry into the field of circular economy with the question: If circular economy is beneficial for the firm both from a business- and an environmental perspective, why are companies not adopting circular business initiatives at a much faster rate? We approached this using a barriers perspective; aiming to identify and understand barriers that are inhibiting the adoption of increasingly circular business models.

In search for an answer we conducted a structured literature study in order to understand and organise current research on the topic. The findings were coded and organised. From the literature, we identified 13 barriers relating to remanufacturing and 8 relating to product-service systems.

Thereafter, we conducted two case studies where barriers to an increased circularity were identified and analysed. The case studies were conducted using a method where a compelling change towards increased circularity were used to elicit rich and relevant data regarding barriers. This method allowed us to observe 8 of the 13 remanufacturing barriers in the first case study. Here, we also identified 2 new barriers. In the second case study we observed 3 of the 8 PSS barriers from the literature search; the method did not allow us to study 4 of the PSS barriers, and 1 was refuted by our findings.

For Volvo Cars Corporation, we highlight the importance of a viable business case for remanufacturing. It is according to our study the financial motivation behind circular initiatives that are lacking, both regarding the economic and environmental possibilities. There is need to link together research on design for remanufacturing with a economic perspective and profitability, and also to find ways to account for the value that remanufacturing creates long after the design phase. Otherwise, circular initiatives are difficult to plan for strategically early on, and will be neglected.

We also identified new barriers in our case study at Volvo Cars Corporation that inhibits circular initiatives. These were previously not addressed by the authors of our literature study. Our findings indicate that the studied organisation may not be fit for putting forward remanufacturing requirements. The competencies needed in order to formulate remanufacturing requirements are split between departments.

Further, procurement, outsourced component design, and the incentives of the suppliers, acts as barriers to remanufacturing. This is something that has not been considered by the reviewed literature, and has clear implications for the possibility of design for remanufacturing. As many authors agree on that design for remanufacturing is key to increased remanufacturing, our finding is of interest. It shows that rather than there being a lack of knowledge regarding design for remanufacturing, there are misaligned incentives and communication shortcomings that are to blame.

For Hr Björkmans Entrémattor we conclude that a change towards increased circularity and a higher degree of utilisation of the product creates operational complexity in a way that is not mentioned in the literature study. Further, people within the company anticipate that a change towards an activity management offer would not be well-received by the customers. Offering activity management can cause customers to doubt the way that the incentives of the provider line up with their own needs, which can cause reluctance despite having other clear advantages.

Our study at Hr Björkmans Éntremattor also allowed us to refute one of the barriers from the literature search. While authors claim that a conflict of interests in the value chain will counteract adoption of product-service systems that lowers the need for new products, our study shows that this is not always the case. In industries with healthy competition and products that are valued on their durability, the conflict of interests from suppliers are of little effect.

To further understand these barrier that inhibits companies from adopting the circular economy, future research is needed. First, the barriers described in this report would should be validated through the studies of other organisations, preferable longitudinal ones. This is especially important for the newly identified barriers that were previously not acknowledged by researchers. Further, there is need to understand the respective importance and prevalence of the different barriers within other firms. While our study suggests that some barriers are more important than others, research that can aid the prioritisation is needed. Finally, the relation between the different barriers and their root causes should be investigated more thoroughly in order to aid the transition towards a circular economy.

From our study, we see that circular economy at the level of the firm is not simply a matter of solving operational issues or awaiting new technical solutions. Rather, circular economy is achieved by finding the right configurations of collaboration between the firm and its external environment where incentives are aligned. Most important is the demand side, were customers' awareness and attitude towards remanufactured or reused products matter. But suppliers and other stakeholders are also important. There is also a need for better methods and models that can capture and present the economic value and business case of circular initiatives properly. Here, future research also plays an important role, and efforts should be made to introduce the perspective of profitability into concepts such as design for remanufacturing.

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