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Efficient Logistics for Circular Furniture Flows

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Abstract

Introducing the concept of circular economy into the furniture industry could help the industry to reduce the waste and environmental impact by recapturing the remaining value of products at the end of lifecycle. The concept of circular economy has been successfully introduced and implemented in other industries like the car industry and the chemical industry. However, the furniture industry is currently still linear focused and is lacking the transition towards a circular economy. One of the reasons for this might be that furniture is generally spoken big and heavy, thus hard to handle and represents a relatively low rest value, this makes the industry hard to transform. Another reason for the lack in the shift towards a circular economy might be a lack of experiences in the industry. As mentioned the nature of furniture makes it hard to handle and transport the items, in order to cope with this an efficient management of logistics is very fundamental to enable furniture companies to move towards the circular economy. In this paper, a general overview of the major constraints and opportunities for the transition towards a circular economy in the Swedish furniture industry will be provided. The goal of the authors from writing this thesis is to study the current situation of the Swedish furniture manufacturers, identify what problems they might face in moving towards the circular economy and propose solutions for the most proper way of dealing with the expected obstacles. The main focus of this paper will be on the logistic problems in remanufacturing, refurbishing and reselling furniture; this includes issues such as warehousing, analysis of centralized and decentralized distribution networks and forward as well as reverse logistics.

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Finally, we would like to note that this thesis project would not have been possible to finish without the help of the interviewees and our supervisor.

Fahad Yousef **Jarno Truijens**

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1. Introduction

This thesis is part of a greater project funded by Vinnova focused on circular business models for the furniture industry in the year 2030. The main goal of the research is to provide potential economic viable business models, which can be used by the Swedish furniture industry in the year 2030 to make the industry more environmental friendly and economically competitive.

Currently, a lot of furniture ends up at landfills, while they might still contain value. Many of the furniture products which are currently disposed are actually still usable and could be used for several years more. However, furniture is mostly replaced due to aesthetic reasons. The remaining value of the furniture is currently wasted and this makes it worth considering new ways to reduce landfill waste generated by furniture products and to look for potential additional profits for the industry. With the shift towards a circular economy, furniture companies can recapture the remaining value of furniture products through refurbishing, repairing or remanufacturing, and reselling them, which could create a new stream of revenue for the actors involved in the supply chain. Recycling is the least favorable solution compared to remanufacturing and refurbishing furniture as most of the remaining value will be wasted with recycling (Linder and Williander, 2015).

1.1 The circular economy

In a circular economy, circular business models are needed to create an efficient flow of materials and to create the most value for the customers. A business model shows how the company operates and delivers value to the customer. A circular business model is a business model that aims at reducing the amount of new materials used in the production process and reducing waste generation in the entire supply chain. This perception means that in an optimal situation there will be no waste as the circular business model captures all products and materials cycles in closed loops. Such a new business model is needed with the emerging challenges such as resources scarcity and high environmental impacts.

Currently, most companies use business models with a linear economic system that ends with the waste stage, in which products are sent to landfills at the end of consumption. However, in a circular economy the business model will aim at recapturing the value already provided to the customers through the reutilization of the product materials at the end of

the lifecycle, instead of having landfills as the end of products lifecycle (Renswoude et al., 2015).

This means that in a closed loop supply chain the products will not go to landfills at the end of the lifecycle, but will be reused, remanufactured, refurbished or recycled. More value can be created with reusing and remanufacturing rather than recycling, and therefore it is fundamental for companies to design their logistic networks in a proper way that supports the return flows and reusing, remanufacturing or recycling processes. However, it is not necessary that the business model will create this closed loop supply chain needed for circular flow. It could be combined with other business models in the entire system, in which other actors in the supply chain are involved as well, this combination can result in a system with closed loops that supports the circular economy. Until now, there are no business models that are completely circular without waste generation. It is hard and challenging for companies to have no waste in the entire system, especially in some industries and products such as fossil fuel that turns into almost absolute waste after consumption (Linder & Williander, 2015).

Since the current business models do not enable companies to have circular flows of materials, there is a need for a transition towards circular economy. Shifting from linear to circular economy requires business model experimentation and innovation to redefine the purpose of the companies and to have major systematic and behavioral changes. Business model innovation is usually a way for start-up companies to enter the market while working in a new way to provide more value to customers; however there are also large existing companies who already came up with new business models for circular economy (Renswoude et al., 2015). Chesbrough (2010) points out that having a business model which supports continuous innovation and business development is fundamental for companies to survive in competitive markets, where customer needs change rapidly. Therefore creative thinking and rethinking the concept of value is required in order to restructure or introduce new business models toward a circular economy.

Coming up with circular business models is quite difficult as it will require a high level of cooperation in the supply chain. Sharing information among different actors in the system is vital to have a responsive supply chain. Having a proper reverse network to get the products

back to the right position in the supply chain is very fundamental for an efficient circular flow of materials, and is very challenging at the same time (Renswoude et al., 2015).

Companies can benefit a lot from having a circular business model as it gives them an advantage over their competitors especially, when it is adopted early. Companies can save a lot on materials if they succeed in getting products back to be reused. Furthermore, companies can generate more profits from the reused and remanufactured products. Having a circular business model will contribute to the firm's reputation as customers will perceive it more sustainable and environmentally friendly, which is likely to attract and retain environmentally aware customers. With circular business models, all companies in the entire supply chain will benefit, but this needs more cooperation and strategic partnerships to be done, and an individual company cannot make it by itself (Renswoude et al., 2015).

Renswoude et al. (2015) mention the barriers companies face in creating circular business models, which are the following:

- Regulations: there is no legal pressure on companies to have circular business models as they are not obliged to take back the products for reusing, remanufacturing, refurbishing or recycling. Neither the customer is obliged to do so.

- Engaging customers: it is not easy to convince customers to give back products once they do not need it anymore. Companies might need to raise awareness by some marketing and environmental campaigns, or they probably have to give incentives to make sure customers will help retrieving products.

- High cost of investments: companies will need to invest a lot in order to have an efficient circular flow of products. This makes it hard, especially for small and medium sized companies.

- Collaboration with other partners: it is hard to have partners along the entire supply chain that would be ready to cooperate to create a circular flow of materials. More problems might be faced deciding who is getting back the products and where they will be stored or remanufactured etc. (Renswoude et al., 2015).

The concept of circular economy is based on the idea of keeping product ownership with the producer or service provider; this makes them responsible for the recollecting and reusing of the products. This means that customers are only users and not owners, and they pay for using the product for a specific period of time, not for owning it. Within a circular economy, companies will reuse products or reuse their materials in the manufacturing of new products. This could benefit manufacturers, especially with the scarcity of resources and expensive raw materials. Manufacturers will become service providers at the same time, which makes them powerful actors in the supply chain with a higher level of control. Furthermore, a circular economy could be a way to satisfy customers who demand sustainable products. A circular economy has the goal of reusing and remanufacturing products without producing any harmful emissions. Moreover, a good circular business model will require companies to redesign their products to make it easier to disassemble and reuse them. Therefore, good use of new technologies and innovation is required to expand the lifecycle of products and reuse material for as long periods as possible. According to the study made by (Rli, 2013) The Council for the Environment and Infrastructure in the Netherlands (2013), many companies started to work towards the transition towards the circular economy, and many companies will clearly adopt the concept of circular economy within 2040.

According to the study done by (Renswoude et al., 2015), there are some characteristics in circular business models that determine the level of circularity of those models:

- The level of product redesign required to implement the new business model
- The responsibility the producer has to the product while it is at the custody of the user
- The level of collaboration and coordination required among partners in the value chain
- Security against resource scarcity and flexibility in using resources
- Additional streams of revenue within the new circular business model

Currently, there are no business models that are completely circular, however, the more these characteristics are apparent and constitutes a big part of the new business model, the higher the circularity the business model will become (Renswoude et al., 2015)

Companies cannot have a successful circular business model without efficient logistics, and therefore logistics is a main prerequisite for the success of the new circular business model. Many companies are moving towards having their customers as users of the product and not owners; this is because manufacturers want to keep control over many materials that are in danger of scarcity. With doing so, manufacturers will have more control even over a bigger part of the supply chain as they would be service providers. The concept of the circular economy means having the market as the primary source of raw materials in producing new products, this implies the necessity of near-sourcing. By near-sourcing, companies consider the cost of the entire supply chain rather than the cost of one actor such as the supplier. Near sourcing is becoming more popular in the U.S as many companies moved their production facilities to their home country. Nevertheless, manufacturers have to take more responsibilities with the circular economy as there will be a need to more efficient reverse logistics and other logistic services, and manufacturers (with their partners) have to be responsible for this as a circular economy will not be successful if customers have to pay or arrange reverse logistics by themselves. Researchers at (Rli, 2013) The Council for the Environment and Infrastructure in Netherlands (2013) expected that transportation problems will increase in cities due to the increase of reverse and service logistics, because many products will be returned or repaired, which will make urban distribution more complex. Therefore, city logistics should be planned for more sustainable good flows management, and cooperation with municipalities is very important for this to happen.

Despite all the benefits a circular economy has, and in addition to the barriers mentioned above, circular business models are sometimes not accepted by different actors due to various reasons. Customers might be the most important players in the success of the circular business model and convincing them is not always easy as not all customers are rational and aware of the benefits of circular economy. Customers might need some kind of incentives in order to send products back after they are done with them. Customers may not be interested in the value of the products at the end of the life cycle; they care more about the original selling price and not about the net present value. They might also prefer owning

the products rather than using it, as circular business models has the concept of keeping the ownership of the product with the original seller while the customer is considered only a user with a long term contract who will send the products back after using them for a certain period. Changing customers' habits will be a challenge for companies planning to create a circular business model as usually customers are satisfied with the status quo and thus it is hard to change their behavior towards embracing the circular economy. Other things in consumer behavior such as social norms play a role in supporting the circular economy. Social norms are subjective where the society sets the acceptable or non-acceptable behavior, and having a regulation that obliges customers to send products back for recycling or reusing does not necessarily create the moral obligation to do so. For this reason, the chance of having a successful circular economy will differ in different societies (Planing, 2015).

Moreover, companies will have to deal with some problems in product redesigning as some products are currently manufactured in a way to be only sold once, without any consideration for reusing them in future. This will require companies to make some investments and other internal changes in terms of redesigning processes and management practices. These are the problems individual companies will face, however looking at the entire supply chain we will realize other challenges that might prevent companies from shifting towards a circular business model. If the supply chain is quite big or actors in the chain are geographically dispersed over different countries, then it will become harder as more coordination is needed and the reverse logistics network will be more complicated. Furthermore, different actors in the supply chain have different interests, and companies who are in the beginning of the supply chain might refuse the idea of having circular economy in case the profit will be generated only at the end of the supply chain. More issues will be faced when deciding who will collect back the products at the end of the lifecycle and where they will be stored and remanufactured/reused (Planing, 2015).

1.2 A circular economy for the furniture industry

Applying a circular flow model for the furniture industry requires efficient reverse logistics. In addition to that, companies need to send refurbished or remanufactured furniture back to the customer, which means they might also need to improve their forward logistics to optimize the supply chain. Some companies will have to restructure their supply chain in

order to be able to maintain sufficient value of the reused furniture. Since reverse logistics is less structured and more complicated than forward logistics, it usually costs companies a lot of time and money and companies might be concerned about a higher environmental impact due to the extra transportation.

Lots of literature on circular flows and reverse logistics has been written in general, however the furniture industry in the current state is quite exceptional since products have a high volume and a relatively low value, which causes large logistical consequences.

Previous research has been done on the environmental impact of reusing furniture in the UK which shows promising potential benefit for the environment (Chapman, 2010). However, it has been based on general assumptions, and it would differ based on companies supply chains and efficiency in reverse logistics.

In order to develop the most beneficial business model for Swedish furniture companies in 2030, further research about cost and environmental impact of reverse logistics is required. This depends highly on the current supply chains of the individual companies and aspects like centralized or decentralized production facilities as well as the retailing channels and volumes. Until now, a pretty detailed overview of production costs as well as the environmental impact of the entire supply chain until the retailer is known for the UK specific (Fira, 2011). Again this is based on general information and this might differ for Swedish companies in general and individually.

1.2.1 Furniture industry from an international perspective

The furniture industry is generally characterized by being a labor intensive sector which is mostly dominated by small to medium sized companies. It is very common for furniture producers to outsource some of their production processes. Worldwide furniture production worth 361 billion Euros, and different national markets differ with their degree of globalization and openness to the global market. The international production of furniture has increased by 60% during the last 10 years. The growth of domestic suppliers in emerging countries and the new production facilities placed by furniture companies from developed countries have contributed to the growth and globalization of the furniture industry. Despite the European Union countries produce 25% of the furniture products in the world, the

European furniture industry is lagging and shrinking in terms of companies and labor, especially in West Europe as production of growth is growing in Central and Eastern European countries. The number of furniture companies decreased from 150,000 to 130,000 between 2003 and 2010, as well as employees' number falling from 1,357,000 to 1,016,000 during the same period. Although the trend of depending on imported furniture material is growing in the EU, only 15% of EU consumption is from imported products, making most EU production of furniture consumed within Europe (CSIL, 2013).

The furniture industry is one of the industries which have future potential by implementing the shift towards a circular economy. Companies can create new revenue streams by reusing and refurbishing furniture. This will not only reduce the production cost, it will also reduce the environmental impact by using less raw materials and reducing waste. Currently, furniture companies are generating huge amounts of waste which is mostly sent to landfills. Within the industry there is a lot that can be done when it comes to waste reduction and reusing materials. According to the Furniture Industry Research Association, the waste generated yearly by furniture companies is one billion kilograms in the UK by itself (FIRA, 2015). Many furniture products are sent to landfill although the products are not at the end of their lifecycle and the conditions of materials are appropriate to be reused again. This makes it worth to consider having circular economy for the furniture industry, which helps in achieving waste reduction targets by reusing materials in refurbishing and remanufacturing furniture products. Remanufacturing is the process of using used products which might be not functioning anymore in manufacturing like-new products with original conditions. Remanufacturing could have different processes or be referred to with different names such as refurbishing, repairing, reconditioning and rebuilding. Nonetheless, remanufacturing is the most common term used in the literature for all these processes. It is mostly common in industries that have high capital investments with long product lifecycle. This includes industries such as motor vehicles, machinery, locomotives, IT products, medical products, electronics and office furniture (USITC, 2012).

Steinhilpher (2001) mentioned that remanufacturing is mostly present in the automotive industry, and the remanufacturing of motor vehicle parts represents 66.7% of the remanufacturing industry. Remanufacturing office furniture is one of the fastest growing industries in the United States. New business opportunities for companies can be found by

remanufacturing and it is beneficial for people by creating more jobs and offering lower prices to customers. Remanufactured products cost around 50% of new products and are sold at around 40%-80% of the new product price, which is beneficial for companies and customers. Companies can offer after-sale services to customers by either collect furniture back or repair and refurbish them at the customer place to be used again by the same customer. Moreover, remanufacturing helps companies to develop their expertise in inspection, reconditioning and repairing. This allows companies to have a better utilization of their technologies and machinery and it encourages business innovation. Also, it is beneficial for companies to remanufacture products rather than sending them to landfill as this will reduce waste as well as create more value for both companies and customers since the materials reused will be cheaper compared to new products and offer same level of product performance. Overall, remanufacturing is considered the most environmentally friendly way for companies to provide their customers with new options (Steinhilpher, 2001).

While remanufacturing makes a new lifecycle for remanufactured furniture, repairing can only extend the lifecycle of repaired furniture products. Repairing is usually done when companies detect failures while inspecting the materials before remanufacturing. The quality of repaired furniture products depends on how defective or damaged the furniture was and the quality of a repaired product might be close to remanufactured furniture if all defects and damages were possible to repair at a proper cost.

1.2.2 Furniture industry in Sweden

Sweden comes in the 19th worldwide ranking as a furniture producer and the 7th largest furniture producer in Europe with a value of 3 billion Euros of furniture manufacturing, which counts to 4% of the furniture production in the EU. The furniture industry has been increasingly important as a part of the Swedish economy, and office furniture counts as 16% of furniture production in Sweden. This is opposite to the situation in most countries in West Europe (except Germany), where the role of the furniture industry in the national economy has decreased especially between the years 2003 and 2010. This also affects the advantages and capabilities the furniture producers in the various countries have such as investments in R&D, technology, innovations and product design in the furniture industry. Sweden plays an

important role globally in the furniture sector as some of the leading furniture producers such as Nobia, Kinnarps and Swedwood are all based in Sweden and are considered international with advanced capabilities, when it comes to product design and innovation. The Swedish furniture manufacturing has developed over the last ten years with an average growth of 2.4% annually. This rate was higher than the average of the EU as other European countries experienced a decrease in their outputs, except for Germany. These rates were also affected by the financial crisis, which also had its effect on the Swedish economy; however the Swedish furniture industry has recovered faster compared to most of the EU countries. Furthermore, Swedish furniture producers outperformed the EU average in terms of labor productivity rates, Return on Equity (ROE) and Return on Assets (ROA) ratios (CSIL, 2013).

The furniture industry in Sweden is in the transition stage of moving towards a circular flow of furniture. Sweden is known as one of the leading countries in sustainability and innovation, where currently research is being done on having a more sustainable furniture flow to reduce waste and environmental impact. Some Swedish furniture companies are testing the feasibility of implementing circular flows by collecting furniture back and repairing or reusing it in new offerings. This might be a result of having good practices of recycling and reducing waste in Sweden, which makes Sweden close to the next step of reusing and remanufacturing furniture as it creates more value than recycling.

1.3 Vinnova project

Vinnova is a Swedish public agency of innovation that promotes sustainability growth through the use of innovation. Many projects are funded by Vinnova, which contributes to making Sweden a center for sustainability and innovation research. Vinnova is not only active in Sweden; it also works on a European level as well as with other international funding agencies and it has many partnerships, thus Vinnova is able to connect companies with universities and researchers (Vinnova, 2016). This thesis project is part of a greater project about circular business models for the furniture industry, which is also funded by Vinnova.

1.4 Problem discussion

Furniture companies are currently at the stage of considering or testing whether the shift towards a circular flow of furniture is financially feasible. This seems to be the first step to a slow transition towards the circular economy, where companies try to figure out the best approach of doing this. Different companies are considering different approaches such as remanufacturing or leasing furniture, providing after-sale services including repairing and refurbishing, or taking back furniture at the end of usage time to reuse or resell it.

However, in order to be able to recapture the remaining value in furniture, companies will have to manage their logistics efficiently. This should enable them to make the collection, repairing, refurbishing, remanufacturing and reselling viable (Linder and Williander, 2015). There are major concerns with regards to handling logistics and transportation. In this paper, the logistic problems in the furniture industry will be discussed and solutions for these problems will be provided. Next to this, this paper deals with the problems manufacturers face with the decision on how to handle the reverse logistics. These problems will include the costs of transportation and packaging, warehousing, collecting and reshipping furniture.

1.5 Research Purpose

This paper exists of two different sections, with two different goals. The first purpose of this research is to provide a clear overview of what specific logistics related issues companies are facing when considering or testing a circular flow of furniture. The second purpose is to develop a framework, which can be used by the Swedish furniture industry. This framework deals with all the issues that arose during the first part of the research and should provide individual companies with assistance in deciding on the best solution given the current circumstances. Thus, the aim of this research is to provide Swedish furniture companies with an insight into the proper solutions for logistic problems in a circular flow of furniture.

1.6 Research questions

The problem as discussed above leads to the following major research question:

- How can furniture companies recover, rework and resell used products in the most efficient way considering the current issues they are facing and the current set-up of the supply chain.

In order to answer this research question the following sub questions will have to be answered:

- What are the major issues regarding logistics, faced by Swedish furniture companies that prevents them from chancing their business model into a circular flow?
- What (logistical) cost aspects do the companies need to take into account when implementing a circular flow of goods?

1.7 Delimitations

Because of the limited timeframe and the scope of this project, this paper comes with a few delimitations. Investigation of marketing aspect of reselling furniture products and cannibalism or the effect on newly produced furniture (potential decrease of sales) will not be investigated in this study. Next to this, potential costs of setting up new sale-networks for reselling furniture or other marketing activities are not part of this report. Also, in 2030, furniture companies might have more modular designs, which will have impact on the logistic costs; however this report will look at the current situation. Not all furniture products are included in the study due to big difference in reworking and logistic costs, which made it necessary to narrow down the scope of the research. For this reason, this paper is mostly focused on office furniture. Furthermore it has to be noted that the research is geographically limited to the Southern part of Sweden.

2. Theoretical Framework

This chapter contains an overview of the literature on which this thesis is based. The literature review covers three areas; Sustainability, Product-service systems and Reverse logistics.

2.1 Sustainability

According to Garetti and Taisch (2012), the first definition of sustainability was formulated in 1987 within the Brundtland Report. They defined sustainability as '... development that meets the needs of the present, without compromising the ability of future generations to meet their own needs. In the past sustainability was mainly focused on the environmental aspect, but in recent literature sustainability is defined with three dimensions: environmental, social and economical. Figure 1 shows an overview of the sustainability covering the three dimensions. Baud (2008) adds a fourth dimension to sustainability, namely technology. In this thesis the focus will be on the environmental and social aspects of sustainability, with technology as a support to achieve a viable business model as shown in figure 1.

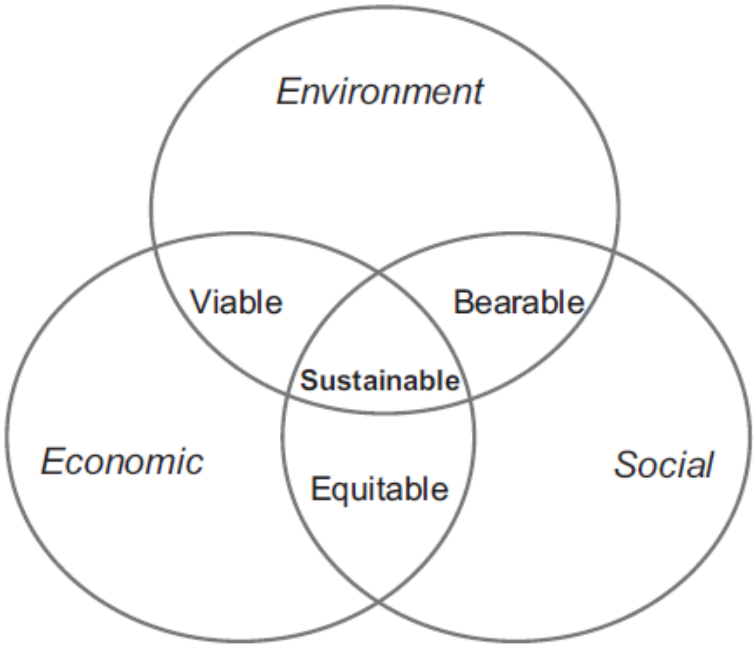

Figure 1: The three pillars of sustainability. Garetti M,Taisch (2012)

2.1.1 Sustainability in furniture industry

According to Parikka-Alhola (2008), the environmental impact in the furniture industry is mostly generated through the manufacturing and the disposal operations. This means that the environmental impact during the usage period is almost non-existent. Furthermore, environmental impact will be generated with the transportation of furniture. This is in line

with the findings of Clarke-Sather (2006), as she mentioned the potential for global warming increases with longer distances of transportation.

Customers in Sweden consider the environmental aspect when purchasing furniture. Eco-design and other environmental European or Nordic labels do influence the decisions of public furniture procurement. Using less natural resources, waste reduction and the possibility of extending the lifecycle of furniture are all considered important factors when purchasing furniture. Moreover, furniture with less toxics and chemicals are preferred as they are considered and less damaging to the environment and human health (Parikka-Alhola, 2008).

2.2 Product-service systems

Goedkoop et al. (1999) describe the definition of Product-service systems as; 'A product service-system is a system of products, services, networks of "players" and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models. Goedkoop further clarifies his definition by describing the three key elements of a Product-service system. Product is defined as a tangible commodity manufactured to be sold. It is capable of 'falling on your toes' and of fulfilling a user's needs. Service is defined as an activity (work) done for others with an economic value and often done on a commercial basis. Finally, a system is defined as a collection of elements including their relations. According to the United Nations Environment Program (2002), Product-service systems are divided into services providing added value to the product life cycle, such as maintenance and upgrading, services providing enabling platforms for customers, such as renting or leasing, and services providing final results to the customers, such as mobility services or warmth delivery. Scholl (2006) mentions that Product-service systems was first mentioned in marketing related research as early as 1973 and have been applied in the field of marketing to enlarge the profit margin of companies, but since the year 1999 the concept of Product-service systems have been used in relation to sustainability. Baines et al. (2007) have conducted a literature review on Product-service systems and identified the evolution of the concept over the years. They confirm the findings of Scholl that over the years the focus of research on Product-service systems has moved towards sustainability. In figure 2 a summary of their findings is given.

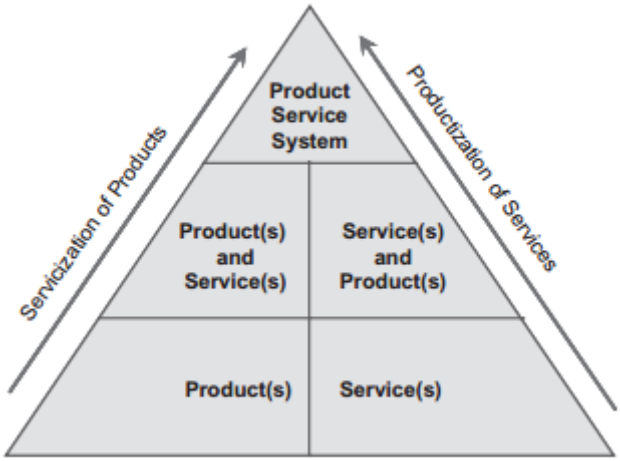

Figure 2: Evolution of the Product-service system concept (Baines et al. 2007)

The major similarity Baines et al. (2007) found in the literature is that although there are different ways on how to offer a Product-service system, it always is an integrated product and service offering that delivers value in use rather than providing a product. Therefore they conclude that a Product-service system offers the opportunity to decouple economic success from material consumption and hence reduce the environmental impact of economic activity. According to Baines et al. (2007) there are three different Product-service systems (PSS) types, namely; Product-orientated, Use-orientated and Result-orientated systems. The product-orientated PSS can be seen as a traditional way of selling a product, but with adding additional after-sales services like repair and maintenance. The use-orientated PSS is seen as leasing or sharing a product instead of selling it. The most radical option is the Result-orientated PSS where companies sell a result or capability like selling laundered clothes instead of a washing machine, where the producer keeps the ownership of the products. Baines et al. (2007) discuss the major benefits as well as the major barriers for the different players involved in making the transition to a Product-service system. The major potential benefits for the producers are an offering of higher value that is more easily differentiated. For the customer it is a release from the responsibilities of asset ownership and to the society at large the major benefit can be found in a more sustainable approach to business. Regarding the barriers, the major issue for consumers is that they may not be enthusiastic about ownerless consumption. The manufacturers at the other hand may be concerned with pricing, absorbing risks and shifts in the organization, which requires time and money to facilitate.

In order to cope with the barriers and to implement a successful PSS, Baines et al. (2007) provide some guidelines. The major advice they provide is that a PSS needs to be designed at the systemic level from the client perspective and that early involvement with the customer and changes in the organizational structures of the provider are required.

2.2.1 PSS for the furniture industry

According to the research of Besch (2005), some companies or researchers had concerns regarding profitability and environmental improvements with the use of PSS. With the use of PSS, the success of furniture companies is no longer linked to the number of new products sold as companies will have revenue streams from the after-sale services provided to the customers. The environmental concerns are not something to be worried about as in the current situation many customers get rid of their furniture because of aesthetic purposes, despite the fact that the furniture could be used for few years more. With a PSS business model, the furniture could be reused either by repairing or refurbishing or by reusing the materials, which will decrease the usage of new raw materials and might also decrease the environmental impacts of manufacturing new furniture products. Environmental impacts can be lowered through the extension of furniture products lifetime, instead of increasing the production of new furniture. However, this might not be the case as research shows that PSS offers of leasing furniture in Germany are mainly considered by furniture producers as new streams of revenue and are not aimed to lower environmental impacts by any means.

Literature in this area suggests that with the use of PSS furniture companies can provide collecting back and repairing or refurbishing services to extend the lifetime of products, which will be perceived as attractive offers, as it is more convenient and easier for customers since they do not need to take care of transportation or repairing as it will be the responsibility of the furniture company (Lidenhammar, 2015).

Despite the benefits the concept of PSS can offer, it comes with some risks and barriers of which some of them were identified by Besch (2005). There is a financial risk as the PSS concept could be costly for the service providers and represent a high financial risk to them if they cannot find customers to lease or rent the furniture for enough time. This means it will be hard to cover the investment cost. Since the majority of the furniture companies are small and medium-sized companies, which will make it harder and more risky for them. Next

to this the small and medium sized companies lack experience and resources to offer PSS of. Furniture producers should consider methods to minimize their financial risk such as introducing offers with minimum rental or leasing period.

The competition in the market is considered another barrier as the competition in the market is high and furniture producers compete mainly on price. Customers are not yet willing to pay a higher price for additional services or for more environmentally friendly products. This means that in the current situation the PSS concept can be implemented successfully only if the PSS offers are cheaper for customers than buying new furniture products. This was also confirmed by the research of Lidenhammar (2015), who mentioned that customers tend to perceive leasing more expensive than buying, especially with repairing and refurbishing fees seen as extra high costs, compared to the traditional way of paying a fixed amount at once, which entitles the consumer to own the furniture. Currently, the concept of leasing furniture does not have strong demand, but according to the study of (Gullstrand Edbring, 2015) it can have high acceptance when there is a temporary need for furniture.

Another barrier to the PSS concept is the lack of interest from furniture companies to make further environmental improvements. Moreover, there is no legislative pressure on furniture producers to reuse furniture (Besch, 2005).

The characteristics of office furniture could represent an obstacle to the implementation of the PSS concept. Office furniture is usually used over a long time (average of 12 years) due to the nature of the furniture which does not need frequent repairing. This might make office furniture not suitable for the concept of renting.

Besch (2005) study shows that furniture companies might need to restructure their supply chain and change their distribution networks which makes a barrier to the implementation of PSS in the furniture industry. The current structure of supply chains and transportation networks could face a barrier to create a cost-effective PSS. Previous research shows that PSS is likely to be feasible with decentralized systems. From a logistical perspective, the PSS concept for the furniture industry could be viable if the distance is not considered long and the volumes are sufficient to support the implementation of PSS offers. Products as bulky as furniture should be moved as little as possible to lower environmental impact as well as cost

of transportation. Therefore, researchers emphasized on the importance of having regional service providers that are able to provide PSS offers (repairing, refurbishing, taking back etc.) to customers close to their locations.

Next to the barriers mentioned above, there are additional barriers that could be foreseen. Furniture companies will face a difficulty in dealing with the cultural shift from traditional practices of buying and owning the furniture to leasing or renting furniture which will be used by consumers and not owned by them. This is due to the fact that there are not many PSS offers in the furniture industry. Moreover, customers tend to perceive that they should either lease or buy furniture, although they might be able to buy some pieces and lease others, but this is usually not perceived as an option for customers. The renting or leasing concept might be viewed by customers as not favorable due to the risk it has if customers damaged the furniture, which might cost them a lot. In addition to that, there are other psychological and social factors which might represent another barrier to PSS such as social image and the fear of being judged by others, and personal attachment to products (Lidenhammar, 2015).

The acceptance of PSS and collecting or buying back furniture from consumers is influenced by the factors mentioned above. Therefore, customers should be given incentives to enhance their acceptance to the PSS business model. These incentives could be offered in different forms, and the use of incentives and their effectiveness in increasing the acceptance of PSS business model might differ to some extent in different countries.

Lidenhammar' (2015) study involved the use of questionnaires in the UK, which was conducted with furniture consumers online and in-store questionnaires in Sweden, who were conducted at IKEA in Helsinborg (Sweden). The result of the questionnaire in the UK showed that consumers were mostly attracted by the convenient way of disposing their furniture by having it picked up by the furniture company as well as by the environmental improvements they can make with giving back their furniture to the company at the end of consumption time. So their acceptance of PSS model was related to the easier way for them in getting rid of their old furniture and the good feeling they would get by contributing to lowering the environmental impact caused by the manufacturing of new furniture products.

These findings match with previous research that showed PSS offers were accepted more in the clothing industry due to the environmental improvements they can achieve.

On the other hand, the questionnaire made in Sweden revealed that customers were attracted firstly by the financial incentives they can get if they give or sell back their furniture at the end of lifecycle, followed by the convenience and the environmental improvements that PSS offers have. It should be noted here that the convenience factor is considered very important in the furniture industry due to the nature of furniture products. This means that furniture companies can make their services more appealing to customers if they take the responsibility of transportation and picking up the furniture from the customers place.

Research done by Lidenhammar (2015) revealed that the furniture industry is quite unique in the sense that it is essential for furniture companies to offer picking up the furniture from customers place to increase the acceptance of their buying-back services. Without taking care of the transportation in taking back products, PSS offers will likely be not appealing enough to the customers. The study also revealed that customers in Sweden and the UK are concerned about the way the furniture will be collected back; therefore communication with consumers is very important in order to answer their questions and address their concerns with regards to how taking back furniture would be done.

Although furniture companies can be responsible for picking up the furniture from customers, some customers still want to decide where their products should end up, such as going to charity organizations. From an economic perspective, this will be challenging for companies as it might not represent any revenue streams for them and might make it worthy to have some partnerships with charity organizations (Lidenhammar, 2015).

2.2.2 Charity organizations

In addition to reselling furniture after collecting it, Curran and Williams' (2010) study in England and Wales showed that many reuse organizations collect furniture back from individuals to use them in charity organizations. In this case, households will contact charity organizations when they have furniture that they do not need anymore, but still is in a usable condition. This furniture will be collected by those organizations and distributed later on for the people in need for furniture. We note here that the collection process will differ based on organization resources and the location of donors. One of the things that those

organizations do different from furniture companies is employing only a limited number of paid workers as most of their workers are volunteers. However, those organizations might be limited with vehicles, as the collection process requires a large number of vehicles. Since charity organizations usually have very small fleets, this might prevent them from collecting large amounts of furniture. The study showed that charity organizations are also not able to store a big amount of furniture and some of them are renting warehouses and storage facilities out of the cities as this is cheaper for them.

2.2.3 Re-use organizations

Reuse organizations are those organizations that offer bulky waste collection services where they collect bulky waste from households. All types of furniture are considered bulky waste and therefore reuse organizations will collect it. This is usually done by local authorities, for free in many countries, but reuse organizations do this to increase the amount of reusable items in the furniture industry and it is also considered a source of income for them. That means reuse organizations and local authorities are both collecting bulky waste, which lowers the amount of bulky waste collected by local authorities. Many reuse organizations were funded because of their skills and expertise in collecting bulky waste, others were not funded but still collecting waste to provide reused furniture and other appliances for people in need. Allocating more funds and support from local authorities will likely make reuse organizations more effective in collecting back furniture from households.

However, demand for both charity and reuse organizations are not that high when being compared to the investments or funds required to carry out the recollection operations. Such organizations should put more efforts to make sure they are reaching their target as many donors might not be aware of those reuse and charity organizations. Since they are operating in the reusing of furniture where products have lower remaining value, organizations should have low operation costs in order to be able to recollect furniture. There is a need of introducing circular business models that are special for charity and social organizations as they operate differently. Research showed that 80% of the items collected by charity and reuse organizations were used, and reuse organizations could achieve a reuse rate of 40% compared to 2%-3% achieved by local authorities' recollection process. Charity and reuse organizations are currently not working together, although they could

complement each other, and therefore they should be brought together and plan their operations to provide the most value for the society (Curran & Williams, 2010).

2.3 Reverse Logistics

According to Brito and Dekker (2003), who conducted a literature review on Reverse Logistics in 2003, the first definition of reverse logistics is given by The Council of Logistics Management (CLM) and dates from the early nineties. They define Reverse logistics as "the term often used to refer to the role of logistics in recycling, waste disposal, and management of hazardous materials; a broader perspective includes all relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials and disposal." Brito and Dekker (2003) state that the first definition of reverse logistics originates from a waste management perspective. Over the years a lot of research has been published on return logistics and many definitions can be found. The largest transition the definition of reverse logistics has made over the years according to Brito and Dekker (2003) is the including of marketing aspects as well as environmental aspects. The definition of reverse logistics is defined by The European Working Group on Reverse Logistics as "The process of planning, implementing and controlling flows of raw materials, in process inventory, and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal".

This perspective on Reverse Logistics covers all different aspects like production, warehousing and transportation as well as the different players involved in the supply chain, therefore this definition of reverse logistics will be used in this thesis.

Next to reverse logistics other definitions like return logistics, retro logistics or reverse distribution are often used in literature. According to Brito and Dekker (2003) they are used in a similar way and can be considered as the same.

Kim et al (2006) mention that Reverse logistics can be categorized in various types according to the product recovery option. Thierry et al. (1995) suggest various product recovery options as direct reuse, resale, repair, refurbishing, remanufacturing, cannibalization, and recycling.

In 2008, Pokharel and Mutha (2009) conducted a content analysis on the published literature on reverse logistics. In their content analysis they under scribe that research and practice in reverse Logistics are focused on all aspects of reverse logistics. In order to quantify the

amount of research which has been done in different areas concerning reverse logistics, they made an overview which can be found in figure 3.

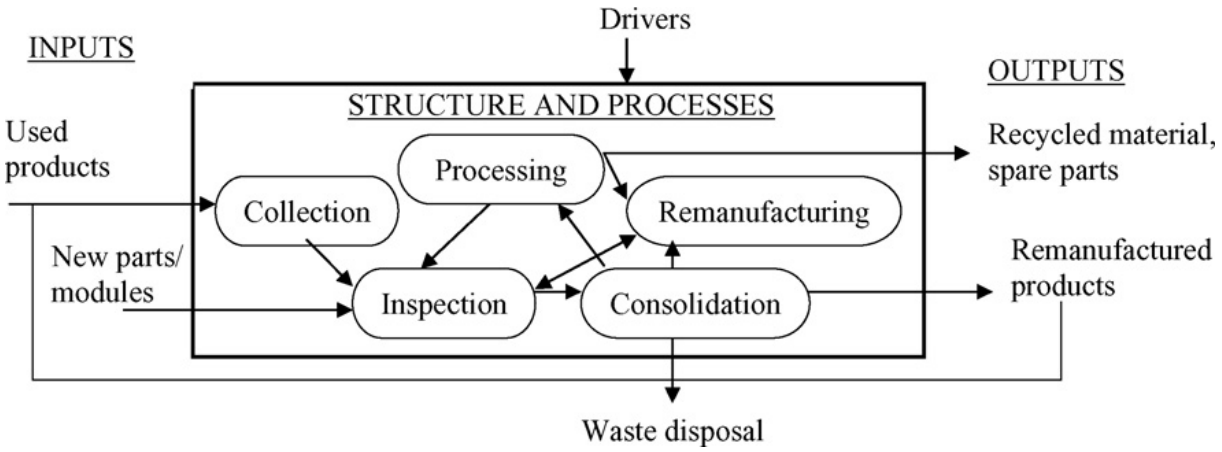

Figure 3: An overview of Reverse logistics. (Pokharel and Mutha 2008)

For their analysis they divide reverse logistics into four main categories, namely inputs, structures, processes and outputs. Although different structures might be suitable, it provides a good starting point to see which aspects are involved within reverse logistics. In the input section Pokharel and Mutha (2009) diversify between inputs and collection, where input is more focused on incentives on how to establish a return flow of products and collection focuses more on the question where to collect return goods.

In the reverse logistics structure section the following categories are distinguished; general, inspection and consolidation, integrating manufacturing and remanufacturing and product modularity. At the reverse logistics processes Pokharel and Mutha (2009) include disassembly, remanufacturing, supply chain planning, coordinating, inventory control, and after-sales services. In the final section, reverse logistics outputs they diversify between product pricing and competition and customer relation.

According to Tibben-Lembke and Rogers (2002), reverse logistics differ a lot from forward logistics as it is more complex and hard to predict. One of the mistakes that could be done in reverse logistics planning is assuming that its cost will be equal to the cost forward shipments. Reverse logistics are not as simple as a repetition of same processes in forward

logistics, usually more things are involved which could cost more money and time. Reverse logistics are more difficult to forecast as customers are the ones who initiate the process. Reverse logistics managers should arrange with the marketing department to be able to have better predictions of returned products based on the number of products sold within specific period and other information about marketing activities.

The first difference is in transportation, in forward logistics transportation starts from one original point where products are sent to many destinations, while in reverse logistics transportation products are moved from several origins to one main destination, assuming a centralized system is used to collect products back. Furthermore, the route of products is known with forward logistics but not clear with reverse logistics, which means more time needed to decide on final destinations of returned products.

Packaging is also different in forward and reverse channels, in forward logistics products are protected with complete packaging and they can be palletized and handled easier and without difficulties. On the other hand, there are packaging problems with reverse logistics as returned products might be with incomplete packaging or packaged improperly which results in more damages to returned products. Moreover, because returned products are not packaged properly they are harder to handle and cannot be stacked easily as products in forward logistics could be stacked (Tibben-Lembke & Rogers, 2002).

The inventory cost in reverse logistics might be lower or higher than forward logistics, but inventory will cost more if demand of remanufactured products is lower than the supply of returned products. Inventory cost can be even higher in industries like the automobile sector, where some companies such as Mercedes does not allow disposal of returned engines, making inventory holding cost even higher for the company (De Brito and Dekker, 2003).

In general, transportation costs are higher with reverse logistics as the volume of product returns is smaller than forward shipments. This leads in general to lower vehicle utilization rates. With different types of products and improper packaging it becomes difficult to palletized products in a standard way, which also leads to lower utilization rates. Next to this, the costs of collection are higher with reverse logistics as it is less standardized process. Furthermore, the handling costs are higher with reverse logistics as shipments are smaller

and workers are needed to identify the disposition of returned products. Administration cost could be higher with reverse logistics as workers might take time trying to identify the stock-keeping number of the returned products and to figure out who the producer is in case products are returned without packaging (Tibben-Lembke & Rogers, 2002). This is also what was mentioned by De Brito and Dekker (2003) on returned products and the need to inspect, sort and reprocess them. Since the value of returned products is generally lower than forward logistics, transportation and holding cost in reverse logistics represent higher percentage of the product value.

2.3.1 Crowdshipping

One of the possible ways of handling shipments is by making use of crowd shipping. Crowd shipping means the delivery of goods or parcels through travelers or ordinary people whose destinations are close to the delivery route. This means that the transportation and delivery of items is done through individuals who are neither working for transportation companies nor employed by the sending or receiving party. Crowdshipping is not a new concept in delivering items, it has been used in the past when people did not have enough delivery couriers and it was the cheapest way of delivering items, or even the only way for some people. As Archetti et al. (2015) point out; this is related to the notion of "sharing economy" in which individuals use their own assets to deliver a service, especially expensive assets such as cars. With that they can be fully used by sharing assets with others to avoid keeping assets unused and to make money. With crowd shipping, companies do not need to invest in vehicle fleets and drivers, which many small companies are unlikely to afford. Crowd shipping is also seen as an innovative solution for transportation problems such as last-mile and same-day deliveries as individuals are given incentives to take care of those deliveries (Archetti et al., 2015).

Crowd shipping startup companies aim at making buying or selling experiences easier by crowd sourcing delivery and they can work in different ways. Some crowd shipping startups focus on retailers, restaurants and other types of personal shipments, while other crowd shipping startups such as Deliv, made partnerships to provide retailers in more than 660 malls with one delivery system. For instance, a customer who buys several products from different stores in the same mall can get all the products delivered to his or her address in one delivery within two hours (Botsman, 2014).

Savelsbergh & Woensel (2016) mentioned that Amazon is trying to explore similar possibilities of what Walmart is aiming to achieve. Walmart is trying to adopt the concept of crowd shipping even further by delivering items ordered online by customers through in-store customers who are leaving the store. However, Savelsbergh & Woensel (2016) argued that deliveries could be done by proper occasional drivers that can come to pick up deliveries, which requires a good prediction of arrival of delivery orders as well as availability of occasional drivers. The usage of appropriate occasional drivers is very important as by the time more deliveries will be done to satisfy customer demand, and companies can create a part of the resources required to handle these deliveries, which are the occasional drivers. The number of occasional drivers could be increased over time and are most likely to cost companies less than transport companies or hired drivers, since they do not have to be employed and they do not need to come back to the store after goods delivery. Moreover, occasional drivers could benefit by earning money as well as controlling the amount of work they do.

According to Archetti et al. (2015), crowd shipping was considered as an innovative solution by some companies such as Walmart and Amazon. A quantitative study was conducted by Archetti et al. (2015) about potential benefits on last-mile delivery with the use of occasional drivers and they found that there is a great potential for sharing transportation resources between individuals. They have also found that significant shipping cost reductions can be achieved if crowdshipping is done through large number of people who are very flexible in making deliveries. This should be achieved by offering proper incentives to individuals through introducing a cost-effective compensation scheme, which is considered a challenge in the implementation of crowdshipping (Archetti et al., 2015).

Slabinak (2015) mentioned that crowdsourcing delivery was used by DHL MyWays in Sweden. Despite the advantages of crowdshipping in providing same-day deliveries and minimizing shipping cost, it turned out that many problems and risks such as thefts, fraud and unsecure deliveries can occur. Despite of being used since a very long time to deliver items, crowdshipping in a business context is a modern approach. Therefore its feasibility and reliability needs to be studied further before being adopted by businesses. In Germany, Shopwing is an example of a failure of crowdshipping service which was stopped later on (Slabinak, 2015).

2.4 Centralized and decentralized facilities

A high centralization of a company's supply chain means having only a few remanufacturing facilities that serve the whole market, while a high level of decentralization means having more remanufacturing facilities with the same operations, where each facility serves the market demand close to its location.

In a study by Clarke-Sather (2006) different variables were considered and she discovered that the potential reduction of global warming and the reduction of transportation costs, dependently and independently, are greatly influenced by the distance of traveling. Therefore decentralization by locating service facilities close to the demand was the more favorable strategy in choosing facilities location. Her findings showed that the number of decentralized facilities increased parallel with the increased rate of product returns.

Centralization becomes more necessary if the facilities have high fixed cost and require large investments to operate. In this case, it is cost-efficient to centralize some operations while decentralize others in order to reduce the cost of transportation. Additionally, centralization is considered the optimal solution when companies are taking back low value products, but in high volumes. A study made by Savaskan et al. (2001) considered economies of scale in taking back products from the customers either through the manufacturer, retailers or other third parties. In her study, she used a forward and reverse supply chain network model to identify the most efficient way of taking back products. In her model, she considered factors like demand, returned product quality, revenue and return rates. She found taking back products through retailers as the most profitable way and using third parties as a very costly way to collect products from customers. Moreover, the study showed that the process of taking back used products is the most efficient for all parties in the network if done through the retailers.

3. Methodology

In this chapter an overview is given on how this research is conducted and which methods are used.

3.1 Conceptual framework

3.1.1 Purpose

According to Yin (2009), there are three main categories in which research can be divided, namely; exploratory research, descriptive research and explanatory research. This research will cover both the exploratory aspect as well as the descriptive aspect. According to Babbie (2007) exploratory research is used when the topic or issue is new and when research is in a preliminary stage. Exploratory research is considered flexible and can address research questions of all types (what, why, how) and is often used to generate formal hypotheses. Descriptive research is defined as attempts to explore and explain while providing additional information about a topic. In the first part of this report hypotheses will be created based on primary data, as well as with the help of literature. In the second part industry specific data will be collected and the created hypotheses will be tested.

3.1.2 Abduction

In empirical research there are three general approaches to use the collected data with theory, namely the deductive approach, the inductive approach and the abductive approach. The definition of deduction is given by Saunders et al. (2012) as the best suitable approach if one's research starts with theory based on readings from literature, later leading to the design of a suitable research approach in order to test chosen theories. Deduction is often used to form hypothesis based on the theory and to test them with empirical data. On the contrary induction is stated by Saunders et al. (2012) as when you are collecting interview data to explore a phenomenon and as a result you generate or build a theory. Abduction is mentioned by Saunders et al. (2012) as the collection of data to explore a phenomenon, identify themes as well as explain patterns as a way to generate and modify an existing theory, just as a deductive approach. But the researcher also collects additional data, just as an inductive approach, in order to test the theory'. In this report the abductive approach will be used since the existing literature will be tested with the empirical data. Next to this the empirical data will lead to hypotheses which will be tested.

3.2 Case study

For this thesis the authors have decided to conduct a case study research. According to Yin (2009), the case study method allows investigators to retain the holistic and meaningful

characteristics of real-life events. The distinctive need for case studies arises out of the desire to understand complex social phenomena. Case studies are used as a method to understand a real-life phenomenon in depth, and such understanding encompassed important contextual conditions, because they were highly pertinent to the phenomenon of the study. According to Yin case studies are specifically useful when three requirements are met. The first requirement is that the research questions of the study should be focused on How and Why questions. The second requirement is that the investigator has little control over actual behavioral events and the third requirement is that the focus should be on contemporary events rather than historical events. Since this thesis investigates a real-life phenomenon and all the three above factors are applicable, the researchers have chosen to go with the case study approach.

3.3 Research Design

According to Philliber et al (1980), research design is as a blueprint for your research, dealing with at least four problems: what questions to study, what data are relevant, what data to collect and how to analyze the results. Contrary to other approaches, case studies do not have an explicit way of conducting the research. However, according to Yin (2009), there are five components of a research design which are especially important:

1. A study's questions;
2. Its propositions
3. Its unit(s) of analysis;
4. The logic linking the data to the propositions; and
5. The criteria for interpreting the findings.

This thesis will follow the five mentioned components as suggested above.

3.3.1 Study's questions

As mentioned above this thesis uses both an inductive as well as a deductive approach. One of the advantages of case studies is that empirical data can be used in both ways. The research questions have been composed based on an extensive literature review, as well as input derived from the interviews conducted with the various companies. In line with what was mentioned above, the most appropriate research questions will start with Why or How.

A good overview of how both approaches work is given by A.D. de Groot and can be found in figure 4.

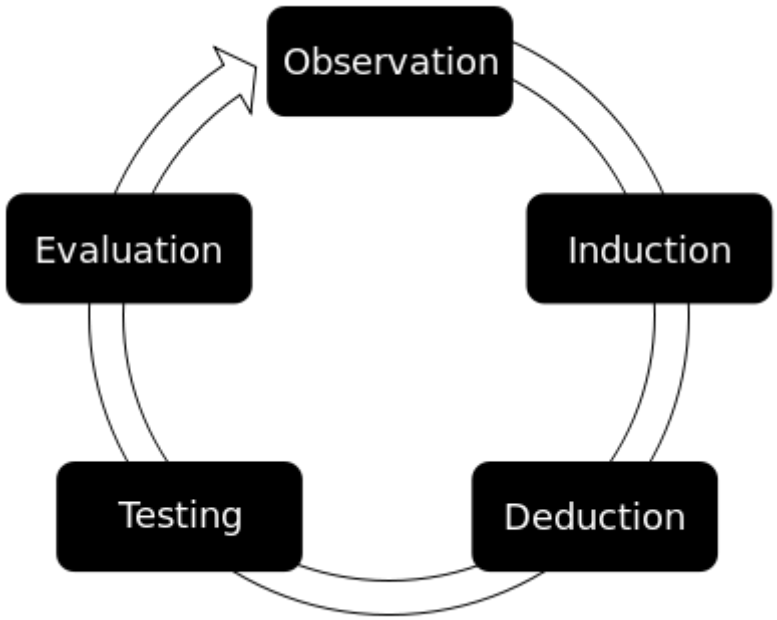

Figure 4: empirical research approach A.D. de Groot

Based on this data, the following research questions have been composed over time:

- What are the major issues regarding logistics, faced by Swedish furniture companies, which prevents them from chancing their business model into a circular flow?
- How can furniture companies recover, rework and resell used products in the most efficient way considering the current set-up of the supply chain.

The abovementioned questions were composed as a result of the literature review and the interviews conducted by the authors. Currently, the furniture companies in Sweden are not making use of the opportunities available in remanufacturing and reselling furniture. There are different obstacles that might stop companies from the transmission towards the circular economy in the furniture industry. Both previous research and interviews with furniture companies showed that companies can provide their customers with new offerings through remanufacturing and refurbishing furniture. This will make the Swedish furniture manufacturers more sustainable as they will be able to use the remaining value in the furniture products at the end of using time, rather than wasting

this value by sending the furniture to landfills. Based on this, there might be a potential to increase their revenue for the furniture manufacturers as well as their retailers.

3.3.2 Propositions

According to Yin (2009), propositions are useful to stir the research into the right direction. The propositions are likely to fall out from the research questions as identified in the previous step. For this thesis the decision has been made to formulate a few hypotheses which will be tested with the empirical data. The following hypotheses have been conducted:

H0: The shift towards the circular economy in the current situation is not viable in the Swedish furniture industry.

H1: Recovering used furniture directly from the customers, transporting them to the manufacturer, refurbishing and reselling them is viable in the current situation.

H2: Recovering used furniture from the customers, storing them temporary at the retailers, bundling the transport towards the manufacturer, refurbishing and reselling them is viable in the current situation.

3.3.3 Units of analysis

For this thesis an embedded single case design have been chosen. The multiple units of analysis can be found in economic and environmental aspects as well as the different stakeholders. Although various sources have been used in order to conduct the data, a single case study design is chosen to be more suitable since the nature of this study requires an anonymous overview of the company specific data. Therefore this data will be composed and turned into industry average figures, which leads to a single case design. In this study the cases have been carefully selected so they predict contrasting results but for anticipatable reasons. Based on the careful selection of the case studies it is likely this will lead to an applicable theoretical framework. According to Yin (2009) a requirement is that the framework needs to state the conditions under which a particular phenomenon to be found. The framework has been designed for the furniture industry in the Southern part of Sweden based on the current set-up of the various actors in the supply chains.

3.3.4 The logic linking the data to the propositions

According to Yin (2009), there are four general strategies to linking the data to the propositions. In this thesis both qualitative as well as quantitative data will be used to test the hypotheses. The qualitative data has been achieved by conducting interviews with various furniture manufacturers. The quantitative data is mainly based on secondary data, more information on how this data has been found and why the authors have decided to use this data can be found in 3.4.

3.4 Data collection

During the empirical study, the researchers will collect both primary and secondary data.

3.4.1 Primary Data

Primary data is the data originally collected by the researchers through sources such as focus groups, experiments, questionnaires, interviews and observations (Hair et al., 2007) Primary data will be collected in this research through semi-structured interviews with furniture and transportation companies to better understand what issues the companies in the furniture industry have or might face when moving towards a circular flow model. The interviews have been conducted via telephone, e-mail and face-to-face. Although the way of conducting the interviews have been done in different settings, the authors have tried to make the collected as uniform as possible by asking the same questions. The interviews have been conducted with the logistic managers of the companies.

3.4.2 Secondary Data

Secondary data is defined as the existing data which is already collected by other researchers or companies for other research purposes and published or could be available for others to use. The use of secondary data cost less money and time when compared with primary data. Secondary data sources include articles, newspapers, published books and journals, websites of governments and non-governmental organizations (Hair et al., 2007).

Secondary data has been used to have a better understanding on how furniture companies currently operate in terms of supply chain structure and reverse logistic channels compared to other industries. The data have been collected by conducting a literature review for which the authors have used scientific articles, books, company websites and their annual reports. Next to this the researchers have also used secondary data to look into the cost of

transportation and warehousing for the manufacturing industry in Sweden. Reports have been consulted in order to indicate which logistical cost aspects should be taken into account by furniture companies when making the shift toward a circular flow of goods. The authors have decided to make use of secondary data; due to the fact the primary data from the companies was case-specific and confidential. In order to increase the reliability of this report secondary data have been used to base the calculations on.

3.5 Data analysis

According to Collis & Hussey (2009), data analysis is done through the use of the proper methods for analyzing the collected data. Researchers make choices with regards to data analysis methods depending on the research paradigm and the type of collected data. Regardless of the method used for data analysis, data reduction is necessary, which is done by reducing the data by getting rid of all the data which is irrelevant to the research topic and not of the researcher interest. In this research, the researchers will use scenario analysis where different possible alternatives will be analyzed and presented. The reason behind this choice is the different structures of furniture companies supply chain as there is not only one way of moving towards a circular flow of furniture, but each company has different possibilities and has its own way of handling logistics.

3.6 Validity and Reliability

Hair et al. (2007) point out the importance of validity and reliability of data as they are two essential concepts and assessment tools in research that are used to measure the quality and errors in the research.

3.6.1 Validity

Research validity refers to the extent to which the researchers were able to measure what they were actually trying to measure with their research, and not other things. Detailed explanations of the research problem increase the validity of the study. According to Collis & Hussey (2009), negativism or interpretive studies have high validity associated with low reliability as the actual research might affect the elements studied and therefore repeating the research under new conditions will not give the same results. The extensive literature review conducted by the researchers, combined with the interviews with furniture companies are valid methods which enhances the validity of the study.

3.6.2 Reliability

Reliability of data measures how similar the obtained results by the researchers could be if the same study was repeated again. Studies have high reliability if there is no difference in the results when repeating them under same conditions. Mostly, entirely quantitative studies have high reliability because of generating same results which makes their repeatability very high. The reliability is ensured by using semi-structured interviews, with people that have the same position within the organization. Next to this, the secondary data which is used leads to a high level of reliability, due to the fact the data is online available and can easily be checked and reused.

4. Empirical Data

We note that in this section we only include the information the authors are allowed to publish. Sensitive data and other figures cannot be published due to the confidentiality agreement made with the two interviewed Swedish furniture companies. The authors are not allowed to mention the name of the companies interviewed.

The authors have interviewed two Swedish furniture companies to gain an insight into the conditions of the Swedish furniture industry. Additionally, questionnaires were used to identify the existing and potential possibilities and barriers for Swedish furniture companies which are planning or already initiated PSS implementation and furniture remanufacturing.

The two companies interviewed have two different visions. The first company has a plan of implementing PSS model by selling the furniture to the customer with a package of after-sale services including repairing and refurbishing services. On the other hand, the second company has a different strategy by selling the furniture to the customer with no repair or refurbish services, but with the offer of buying back the furniture at the time when customers want to sell or get rid of their furniture.

Below is a summary of the data collected through the use of questionnaires and interviews with the two furniture companies.

Company X

- Selling furniture and providing after-sale services (repairing/refurbishing)
- No furniture is taken back for reselling
- Using their own distribution centers and other furniture retailers
- Using private vehicle fleet and other transportation companies
- Sometimes problems are faced in packaging requirements
- High utilization rate of own vehicle fleet
- Warehousing is the major anticipated logistic problem

Company Y

- Selling furniture without any after-sale (repair/refurbish) services
- Taking and buying back furniture at the end of usage period
- Sales through the company and distributors
- Returned products were in good condition – no extensive repairing was required.
- Remanufacturing expected to represent important proportion of company's turnover
- All transportation is done through logistic service providers
- Some problems in packaging requirement
- Warehousing is not a problem, but transportation cost is the biggest concern

It is clear that the two companies plan to move towards a circular furniture flow by extending the lifetime of the furniture they produce, but in two different ways which will be discussed further in the analysis part. What we want to highlight here is that the two companies are still facing some similar problems. The two companies' major concerns were related to logistics. The problems faced and foreseen by the two companies include the packaging requirements imposed by logistic service providers, warehousing facilities and transportation cost. Besides the faced and expected difficulties, the two companies were not concerned about the process of remanufacturing or repairing or refurbishing as well as reselling the remanufactured or refurbished furniture. Furthermore, the two companies did not show any plans of making environmental improvements.

5. Analysis exploratory research

Based on the literature review and the interviews made with the Swedish furniture companies, it is clear that different companies design their PSS offers differently. Some companies provide furniture PSS offers that are product-oriented, which means the customer will get the furniture and be provided with other services such as repairing, refurbishing and/or upgrading. With such services, it is very important that companies are able to provide the buying/taking back services to be able to reach a high recovery rate of used products. If companies do not plan to take furniture back, then it is more cost-effective for them to repair/refurbish furniture at the customer's place, and only when more repairs are needed and cannot be done at the spot then moving it to the closest retailer/showroom would be the solution.

On the other hand, other companies provide furniture PSS offers that are use-oriented, which means they lease or rent furniture to customers for a specific time. Furniture companies can have a successful leasing business if they can provide lower price when compared to purchasing furniture. Again, it is important that the companies arrange taking-back services, but in this scenario without the need to provide customers with any incentives to get the furniture back. Companies can also use a mix of the two PSS offers by leasing furniture and providing repairing/refurbishing services at the same time, as well as collecting or buying furniture back from customers.

Many obstacles might be faced with providing those furniture PSS offers. Using the barriers identified by Besch (2005) and the interviews and questionnaires with the Swedish furniture companies, the foreseen situation for Swedish furniture companies will be as follows:

1. Remanufacturing/repairing/refurbishing of used furniture: the companies interviewed did not have any concerns about repairing, refurbishing and remanufacturing of furniture. It is obvious that companies are capable of extending the lifetime of furniture without facing any major problems in the process of remanufacturing and maintenance.

2. After-sale services: providing repairing and maintenance services is not seen a challenge if done at the same spot, which is the customer's place. This is more cost-effective for companies as in most cases they will avoid the logistic costs of taking and sending back products to the customers. Companies provide those services only to their own products which are sold by them or their distributors and retailers.

3. Financial risk for the service provider: furniture companies see a risk in implementing the PSS as it will require high investments and other necessary changes such as restructuring logistic networks, creating more partnerships or collaborations and increasing warehousing facilities. The financial risk becomes greater especially for the furniture industry as the implementation of PSS by furniture companies is very limited and there are no successful examples until now, but most companies are in the phase of introduction and testing of PSS and at the first stage of transmission to the circular economy. Companies had shown concerns with regards to the very low

demand compared to the investments required. The biggest concern here is the inability of finding customers that are willing to rent the furniture for periods that are enough for the furniture companies to cover their investments.

4. Characteristics of office furniture: the data gathered in the literature review matched with the concerns raised by companies in the interviews with regards to furniture bulky nature. The fact that furniture products are heavy and big in size with relatively low value compared to other products makes it hard to lower logistic costs. This is seen as a serious problem in transportation as companies see a real obstacle in collecting furniture and send them back with reasonable transport cost. Furthermore, achieving vehicle utilization rates is a problem for some companies as recovery rate of furniture is very low. However, one of the companies was very satisfied with the vehicle utilization rates as it was very high, this might be because that company has its own vehicle fleet which allows them to collect raw materials and other spare parts from suppliers on the way back to the factory.

5. Environmental improvements: companies believe that it is not easy to make environmental improvements or lower environmental impacts. However, it is obvious that the environmental side is not the interesting side for them when deciding on implementing PSS, but environmental improvements could be used by companies as a marketing tool. The economic benefit is the major and most interesting thing for them. This matches with what Besch (2005) mentioned about furniture producers in Germany which consider the PSS offers as a purely source of income and not focused at making any environmental benefits.

6. Changes in the structure of the supply chain: companies did not show big concerns when it comes to collaboration with other partners in the supply chain, this might also be due to the fact that one company owns most of their distribution centers. However, changes in the supply chain might be difficult and costly to make. For example, using the retailers as a temporary storage or a service point to repair furniture is appealing to some companies, but they still have no clear vision of how this will be agreed on as the volumes now are very low for such changes.

Furthermore, companies who do not own a vehicle fleet would like to plan the routes of the trucks to better suit their shipments, but it is not possible because they use transportation service providers.

7. Profitability: the companies interviewed are expecting to make high profitability from the implementation of PSS. Profits will be generated through reselling remanufactured products as well as repairing and refurbishing services. The figures show that remanufactured products will significantly cut down production cost for companies, which will enable them to generate more profits. While PSS offers will not replace the traditional business of selling furniture, it will be a big business for some companies as they are estimating PSS offers to represent a big part of their turnover within the next 10 years.

It is important to note here that not every furniture company in Sweden will necessarily face all these barriers, but depending on the situation for each individual company, which could makes the company facing some of these barriers. After conducting the interviews with the furniture companies, it is clear that companies owning their vehicle fleet might not face many transportation problems which are faced by companies purchasing transportation services. For instance, companies using logistic service providers in furniture transportation face some problems such as inability to plan vehicle routes and other requirements set by the logistics provider with regards to packaging of products, all these problems are smaller or could be avoided if companies own their vehicle fleet. Furniture manufacturers could be limited in providing PSS offers due to the requirements of the logistic service providers, however, there are other small companies which are willing to take-back products without any packaging requirements, yet they are limited in their vehicles and logistic network compared to the major logistic service providers.

On the other hand, there are other companies who have no transportation problems, satisfied with their vehicle utilization rates, but they consider warehousing facilities as the major foreseen bottleneck in the implementation of the PSS concept. Currently, warehousing is not considered a serious issue for them, but with the growth of volumes it will be the major concern for them. Moreover, Besch (2005) mentioned in his research

that one of the barriers in implementing PSS is the ability to cope with the fashion trends and new designs in the furniture industry, however this was not a concern at all for the furniture companies interviewed. The companies interviewed believe that providing repairing/refurbishing services as well as selling remanufactured furniture will not hinder them from keeping the pace with the new furniture designs in the industry.

5.1 Centralization vs. Decentralization

Companies planning to implement the PSS model and taking back furniture will need to redesign their forward as well as reverse logistics, which means they will need to make changes and decisions which will make them centralize or decentralize their logistic operations. This is in line with what was mentioned by Clarke-Sather (2009) that the decisions of centralization or decentralization are affected by production operations, customer location and expected amounts of product recovery. Depending on the market, it might be important for some companies to decide whether to locate service facilities close to the customers who are giving/selling back their furniture or close to the customers willing to buy remanufactured furniture. When companies have high rate of buying/taking back products, transportation cost will represent a big proportion of the total cost, which makes economic sense to decentralize facilities and make them closer to the customers. Furthermore, products with high manufacturing complexity make reusing, repairing and remanufacturing more favorable options, and therefore it might be more cost-efficient and environmentally friendly to decentralize production operations of those complex products.

As found in the literature review that previous research suggests that PSS would be viable only with decentralized distribution systems. With decentralization, companies can use their retailers as service providers close to the customers, and this will cut down transportation cost as customers can be reached with shorter distances when there is a need to repair/refurbish or to take-back furniture from them. In addition to the economic benefit, companies can make environmental improvements by moving furniture less and only for short distances.

This was supported by the data gathered through the interviews made by the authors as some Swedish furniture companies have interest in using their retailers or distributors as regional service providers that are close to the customer, but the low volumes of the

products taken back is currently a problem for them to do so. Using the retailers/distributors for repairing and remanufacturing makes it necessary to provide the retailers and distributors with the spare parts as well as the knowledge and skills required to do all repairs and refurbishments.

Besides this, another option for furniture companies would be setting up their own decentralized service facilities once they reach the volumes that are enough to cover the investments required to build up those new facilities, which will be placed in regions that are close to a large number of customers and not in remote or isolated areas otherwise companies will not be able to lower their logistics cost. Setting up new decentralized service facilities means that companies will need smaller central factory as there will be less repairing/remanufacturing processes there, as well as to cut down costs. Yet, production of new furniture will take place at the central facility, which also will provide other service facilities with spare parts and materials required for repairing and remanufacturing processes. What Besch (2005) mentioned was also the case with one of the companies interviewed which they use their own showrooms as service facilities where repairing and refurbishing takes place, there are also other possibilities such as using those showrooms as temporary storage facilities. Currently, some companies started to ship the spare parts and materials needed for repairing services to their own showrooms. However, using showrooms as temporary storage facilities is currently very limited.

Currently, the Swedish furniture companies which are trying to decentralize seem to have more chances in successful implementation of their PSS offers, at least in the first period of the implementation. This is also confirmed by the research of Clarke-Sather (2009) which found that decentralization is better for companies when there is a high need for transportation. From a transportation perspective, decentralization is beneficial because it will decrease transportation cost as well as needed time and labor of taking-back furniture. Centralization is more viable with large economies of scale. However, decentralization is more essential when more transportation resources are required for high product returns. When product recovery is low or not needed, centralization might be viable because of the lower need for transportation. Furthermore, the findings of Clarke-Sather (2009) support the fact that furniture companies can achieve environmental improvements with decentralized service facilities as the environmental impact could be lower with decentralization.

5.2 Crowdshipping furniture

Crowdsourcing delivery is still considered a new practice for many companies, it is still not seen a very reliable way of delivery. The authors could not find any data about crowdshipping furniture or any other bulky items. Also, the companies interviewed are not using crowdshipping and they did not have any plans related to this when the authors asked about transportation and delivery solutions. It might be worth considering establishing partnerships with crowdshipping companies as an extra logistic resource to solve the problem of high cost of transportation, whether in delivering furniture to customers or in taking furniture back from them.

Looking into the crowd shipping possibilities in Sweden, DHL started with MyWays however this service was stopped later on and is no longer available. There are some crowdshipping startups in Sweden such as BagHitch. BagHitch connects drivers with available space in their cars with senders who can check the ratings of drivers and rate them after a delivery is made. BagHitch let senders and drivers agree on the time and price of delivery, and make the payments through the website. All shipments are insured with a maximum insurance of 2,500 SEK (BagHitch, 2016). However, companies such as BagHitch might not be an attractive option for furniture companies as their occasional drivers responsibility is to make the delivery but not handling the products by lifting them to and from the vehicle. Furniture companies would benefit from crowdsourcing delivery if the drivers can handle the furniture as they expect the driver to do this, not the customer.

Considering to crowdsource delivery of furniture might be more difficult than most of the goods crowdshipped nowadays. With crowdshipping, most shipments made are deliveries of parcels and small items. Comparing this to furniture, which is much bigger in size than parcels, more available space in vehicles is needed in order to enable drivers to deliver furniture. This means that to be able to deliver furniture, most of the space in the car should be free, assuming that deliveries are made by saloon car, which is the most likely vehicle used in crowdshipping. This might lower the number of expected drivers to deliver furniture, compared to drivers who deliver smaller items. Furthermore, small products and parcels come in complete packaging, while furniture taken-back from customers is without any packaging, which makes furniture at risk of being damaged. The risk of damaging the furniture is even increased if the drivers making the delivery are not experienced in handling

furniture. For this reason, furniture companies might have to set requirements for crowdshipping deliveries, such as having experienced drivers that have been driving for few years as well as having the experience to handle furniture.

5.3 Discussion

It is obvious that different companies will face different barriers, and the difficulties vary based on the approach companies choose to shift towards the circular flows of furniture. For instance, the barrier of transportation and logistics is one of the major barriers, and it is even more difficult for companies who decided to move furniture more. Furniture companies did not make any changes in their supply chain to support the remanufacturing business; it seems that they are in an early stage of studying the potential for remanufacturing business with limited testing for its viability. However, companies are trying to put more effort which is seen in small steps, such as one of the companies interviewed has managed to work with a transportation company that made it easier for them to move unpackaged furniture. This enables them to overcome the packaging issues in transportation as major transportation providers such as DHL and DB Schenker are not transporting unpackaged goods. Such steps are not considered major changes to the supply chain structure, yet it helps companies to implement their plans with regards to furniture remanufacturing. Companies with long-term leasing offers are more likely able to cover their investments, compared to companies who offer short-term leasing. Furthermore, if companies are able to provide after-sale services efficiently, they might have more potential in retaining customers and selling new furniture to them.

It is also clear from the interviews that the major concern of companies is the reverse flows and how to handle them efficiently. It is not only about recovering furniture, but as well as re-shipping remanufactured/refurbished products which make it difficult for companies to handle logistics efficiently. Crowdshipping is one of the possibilities for furniture companies; however it seems that companies at this stage do not consider using crowdshipping services. This might be due to the other options available to furniture companies by using their own fleets or reliable transportation companies, or it might also be due to the fact that most crowdshipping companies are startups and small companies that are not seen as reliable and experienced as the major logistics service providers.

6. Descriptive Research

After the identification of the major barriers and opportunities for implementing a more sustainable business model for Swedish office furniture industries, in this section an attempt will be made to create a model which can be used by the individual companies to identify the best option focused on the logistic costs. An attempt has been made by the authors to retrieve data regarding the actual costs of the logistic activities within various companies. However, this data turned out to be not available at all, insufficient or confidential. Therefore, other, secondary data have been sought to complements the data retrieved from the interviews to base some of the calculations on.

6.1 Secondary data

Two valuable sources of data have been found, which will be combined together with data from the interviews to use as a basis for the model. The first source used is a survey on the state of logistics in the Baltic region conducted by LogOn Baltic (2007). This report provides very specific data on the various logistic costs within the region Östergötlands län in Sweden. Since this area is close to the location where most of the furniture companies have their headquarters, this data is considered to be very valuable. The other source of data which will be used is a survey by Hansen and Hovi (2010) on the costs of logistics in Norway. This data is a little more detailed on the various cost drivers within logistics. Since the Norwegian costs of logistics, according to the report of LogOn Baltic (2007) do not differ that much, the more specific data provided by Hansen and Hovi (2010) is used to calculate these factors for the Swedish industry.

Based on the input provided by the companies in the interviews, two scenarios will be developed and for each of them a model will be created. The first model will be based on taking back the products after usage from the customers by the producers, refurbishing them and reselling the items. The second scenario will be based on the decentralized theory, where the retailers fulfill a temporary warehouse function.

In the figure below from the LogOn Baltic report (2007), an overview is given on the logistic costs as a percentage of the turnover for manufacturing companies. The data of the survey is composed of 450 manufacturing companies in the eight Baltic countries as shown below.

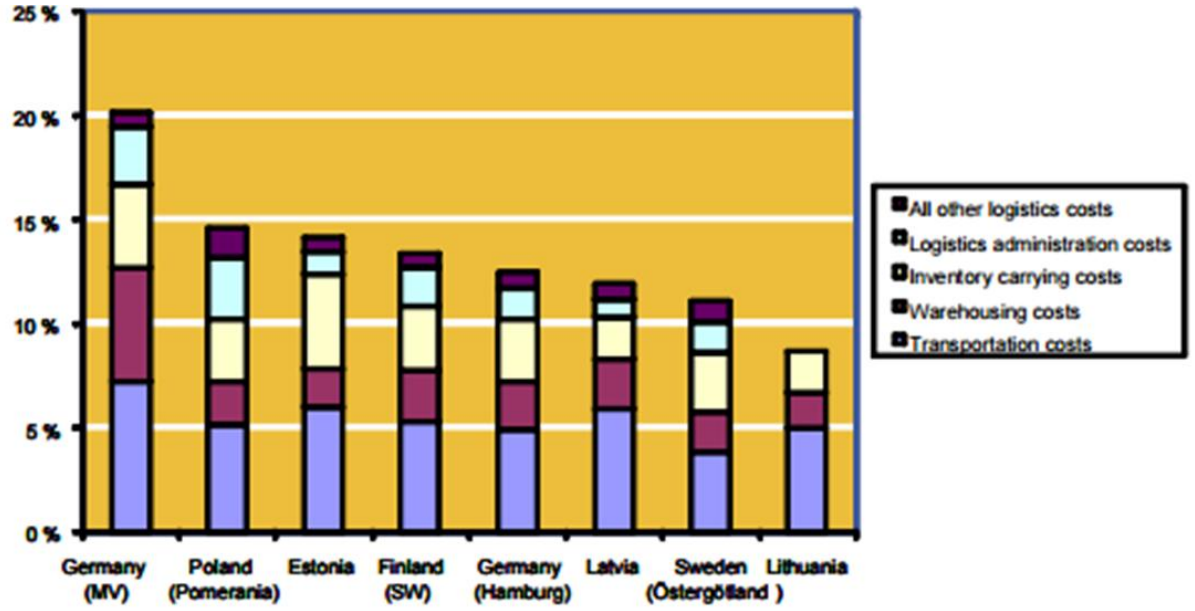

Figure 5: Logistic costs for manufacturing companies as percentage of turnover. Source: LogOn Baltic report (2007).

Looking at Östergötland, the specific data for logistic costs as a percentage of the turnover is 12 %. This data will be used as a reference to build the model on. As can be seen in the figure, the LogOn Baltic report has diversified the various cost aspects of the total logistic costs. This diversification is clearer in the figure below.

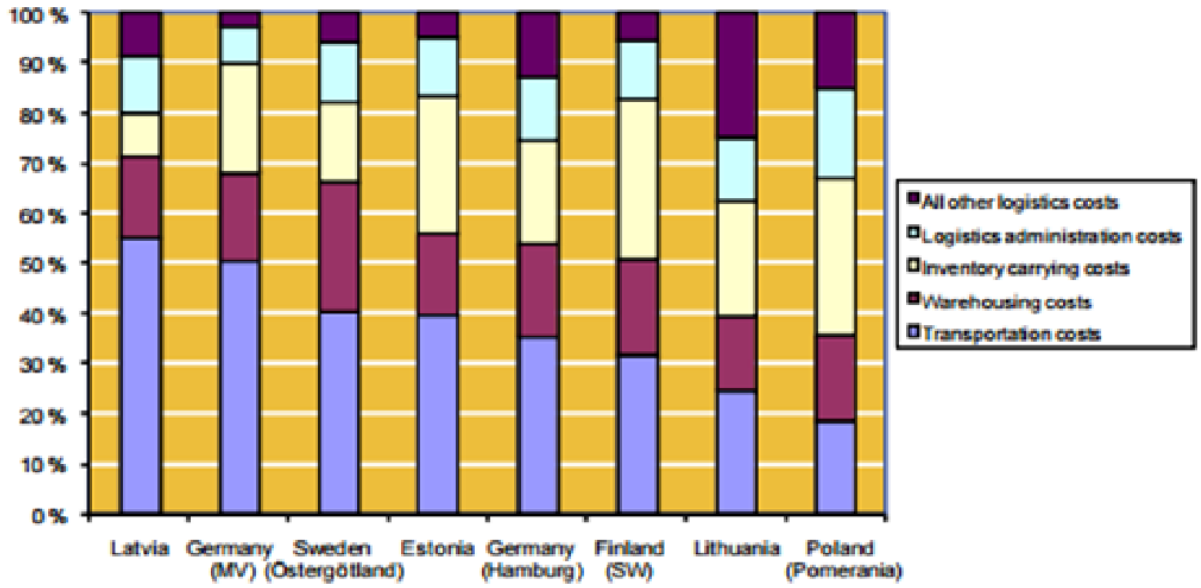

Figure 6: The different components of the various costs of logistic compared to the total costs of logistics. Source: LogOn Baltic report (2007).

The data above gives a good overview on the total costs of logistics in Östergötland and some details as well. However, to fully understand the different aspects of the cost drivers within logistics, further specification is needed. Unfortunately there is no further detailed information on this available for the Sweden specific according to the authors. However, Hansen and Hovi (2010) have done a more detailed survey on this within Norway and compared the data with the LogOn Baltic results. An overview of this can be found below.

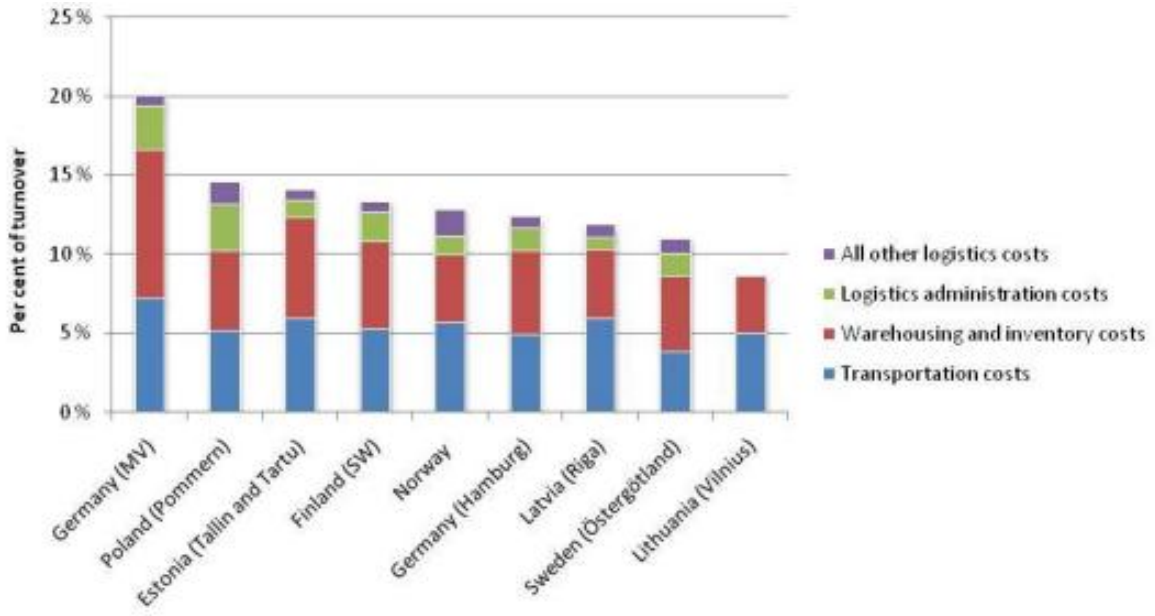

Figure 7: Logistics cost shares for manufacturing industries. Source: Hansen and Hovi (2010)

The reason why this data on Norway is added is the fact that Hansen and Hovi (2010) make a more detailed distinction within the various cost drivers. This result is shown in the figure below.

		Cost component							
		Transport ation	Warehou sing	Cost of capital	Obsoleteness and wastage	Insurance	Packaging	Administr ation	SUM
Unweighted average	Manufacturing	6,03 %	2,97 %	1,36 %	0,71 %	0,41 %	0,60 %	1,04 %	13,11 %
	Wholesale trade	6,04 %	4,94 %	1,34 %	0,93 %	0,18 %	0,35 %	1,23 %	15,01 %
	Building and construction	5,18 %	2,84 %	0,99 %	0,77 %	0,54 %	0,43 %	1,56 %	12,31 %
	All industries	5,88 %	3,51 %	1,30 %	0,78 %	0,37 %	0,51 %	1,17 %	13,52 %

Figure 8: Costs of logistics in share of turnover by industry and cost components. Source: Hansen and Hovi (2010)

The data above on Norway has been used to calculate the individual cost drivers of logistics for Östergötland as well. The result of his can be found in the figure below.

Cost components	Percentage
Transportation costs	40%
Warehousing costs	26%
Costs of capital	5,38%
Costs of obsoleteness & waste	8,67%
Insurance costs	1,62%
Packaging	7,33%
Administration	11%
total	100%

Figure 9: Individual cost components as a percentage of the total logistic costs.

The data above gives a detailed overview on the costs of logistics within Östergötland. The data as provided above will be used in the models.

Next to the relative data on the costs of logistics the authors have searched for absolute data on the costs of transportation within Sweden. According to the authors, the most accurate data regarding these costs are to be found at the Swedish National Road and Transport Institute (VTI). The VTI is an independent and internationally prominent research institute in the transport sector. Their principal task is to conduct research and development related to infrastructure, traffic and transport. The institute has, in corporation with transport companies within Sweden, collected data on using specific software. This data have been published on 2016-03-21 in a report called Kostnader i SAMGODS/ASEK and will be used within the analysis. The report provides detailed information on the average fixed costs of possessing specific trucks, the costs per kilometer of specific trucks and the costs per ton. Due to the nature of the products within the furniture industry, the authors have chosen to use the fixed costs as well as the costs per kilometer for their calculations. The weight factor is not considered as important when it comes to the transportation of furniture.

The data from the following figures will be used to estimate the costs of transportation within Sweden. The VTI has classified five different categories of trucks. The categories can be found below.

Fordonstyp i den här rapporten	Fordonstyp i Så Calc ASEK	Fordonstyp i Så Calc SAMGODS
LGV3	Transport Skåp	Transport Skåp
MGV16	Lokaldistribution	Dragbil 2 axl
MGV24	Anläggning 3axlig o kärra	Dragbil 3 axl
HGV40	Fjärrlastbil	Fjärrlastbil
HGV60	Rundvirkestransport/Interpolering	Rundvirkestransport/Interpolering

Figure 10: Classification of trucks used by VTI. Source: Kostnader i SAMGODS/ASEK (2006)

For the calculations the authors have decided to use the data of the MGV24 and the LGV3. According to the authors a combination of these types of transportation is the most suitable for the transport of furniture. To get the most reliable data, the authors have decided to give the LGV3 a weighing factor of 2 and the MGV24 a weighing factor of 1.

As discussed above both the costs of a truck an hour as well the costs per kilometer will be taken into account. These figures can be found below.

Vehicle	Drivmedel	Service och reparat-ionskostnad	Värdeminskning	Däckkostnader	Totalt
LGV3	1,19	0,316	0,74	0,493	**2,74**
MGV16	3,16	0,596	0,47	0,171	**4,40**
MGV24	3,76	0,57	0,47	0,243	**5,04**
HGV40	4,95	1,139	1,71	0,430	**8,22***
HGV60	6,23	1,139	1,87	0,964	**10,20**

Figure 11: costs per km in SEK. Source: Kostnader i SAMGODS/ASEK (2016)

Vehicle	Kapital-kostnad	Värde-minskning	Förarlön	Skatter och avgifter	Övriga tidsbero-ende kostnader	Försäk-ring	Totalt
LGV3	3,77	19,27	244	1,82	10,42	6,25	**283,71**
MGV16	10,06	23,68	235	5,97	11,81	20,43	**306,95**
MGV24	9,87	23,56	235	6,27	15,10	19,23	**309,03**
HGV40	16,46	26,20	235	7,62	12,07	16,43	**313,78**
HGV60	18,01	28,68	244	7,62	12,35	17,71	**328,37**

Figure 12: costs per hour in SEK. Source: Kostnader i SAMGODS/ASEK (2016)

A combination of LGV3 with a weighing factor of 2 and MGV24 with a weighing factor of 1 provides the following outcome, which will be used in the models.

The costs per km (5,04+2,74*2)/3 gives; 3,51 SEK per km

The costs per hour (309.03+283.71*2)/3 gives; 292.14 SEK per hour

6.2 Scenario 1 Centralized

The first model will be based on taking back the products after usage from the customers by the producers, refurbishing them and reselling the items. This is in line with the results of the interviews with the companies. To see whether this scenario is viable we will make use of the data as provided above from the LogonBaltic report, the actual data on logistic costs in Sweden as provided by Trafikverket, the Swedish transport administration (2015) and based on assumptions from the authors after the interviews with the companies.

The following framework has been produced to see whether or not the option of having a centralized reverse logistics option would be viable for refurbishing and reselling furniture. The fixed variables have been based on the empirical data gathered by the interviews and on secondary data. The two variables that will define whether or not the decentralized scenario is viable are the total value of the products taken back from the customer and the distance from the customer towards the manufacturer. This should enable the manufacturers to calculate the viability of each individual case. It should be mentioned that the profit Margin does not include any costs regarding the marketing or setting up a new sales-network for refurbished furniture. In figure 13 the expected costs of the various aspects of logistics are calculated.

	Based on	**Value in %**
Warehousing costs	26 % of 12 % total logistic costs LogonBaltic	3,12
Costs of capital	5,38% of 12 % total logistic costs LogonBaltic	0,65
Costs of obsoleteness & waste	8,67 % of 12 % total logistic costs LogonBaltic	1,04
Insurance costs	1,62 % of 12 % total logistic costs LogonBaltic	0,19
Packaging	7,33% of 12 % total logistic costs LogonBaltic	0,88
Administration	11% of 12 % total logistic costs LogonBaltic	1,32
Costs forward transport	40 % of 12 % total logistic costs LogonBaltic	4,80
Costs reverse transport	40 % of 12 % total logistic costs LogonBaltic	4,80
Total logistic costs	**Accumulation of factors above**	**16,80**
Reworking costs	10 % based on assumptions	10,00
Compensation previous owner	Assumption 15%	15,00
Total costs	**Cumilation of factors above**	**41,80**
Selling price	50 % of new price based on assumptions	50,00
Profit Margin Manufacturer		**8,20**

Figure 13: Expected costs of logistics based on the value of the products.

The figures above are estimations mainly based on industry averages. The costs might differ for different companies based on specific features of the individual companies. In that case, the assumptions can be changed with actual numbers to give a more realistic outcome. Based on our assumptions and data from the average logistics costs in the manufacturing industry, the profit margin is set on 8,2 % for the manufacturer in the model. Depending on the selling price and the payment towards the previous owner this can easily be adjusted.

The second variable that will determine the viability of the centralized scenario is the distance from the customer to the manufacturer. In our calculations the actual data of VTI is used in order to give an estimation of these costs. This is a simplified model, which calculates the costs of having a truck driving towards the customer and back including a driver. It does not take any potential revenue of the truck company into account in case of outsourcing or potential extra costs due to a low utilization rate in case of using a company owned truck. The usage of other 3PL's have not been taken into account due to the fact they only transport palletized goods, which is not suitable for furniture, in line with the results as one of the main barriers in the interviews. The model assumes departure from the manufacturer, so the distance towards the customer has been multiplied by two. Further the model assumes an average speed of 75 km/h and one hour for loading and offloading the truck.
It has to be noted that the model is based on the total costs of logistics for the Swedish Manufacturing industry. The overall tendency in the literature is that Reverse logistics is in general more expensive than forward logistics. However, the authors have decided to stick with the secondary data for two main reasons. The first reason is that although there is an overall tendency in literature that reverse logistics is more expensive, there is a lack of support on how much the actual cost would increase. In order to make the model as reliable as possible, the authors have therefore decided to not make an assumption on this. The second reason why the authors decided to not adjust the secondary data can be found in the fact that the data from LogonBaltic takes the overall costs of logistics into account, so both the costs for forward logistics as well as the costs for reverse logistics. So despite of the fact it is arguably that certain aspects like the costs of administration and transport might be a little higher, proper data was missing and the authors have decided to use the data, which is as close to reality as possible.

Variable	Input	Based on
Distance (km)		
Costs per km in SEK	3,51	Data VTI
Costs total km both ways	(Distance*2)*(cost per km)	
Hours of usage truck	(Distance in km/0,75)*2+1	75 km/h + 1 hour loading time
Costs of usage truck per hour	292.14	Data VTI
Costs using truck x hours	Hours of truck*costs per hour	
Total transport costs	Costs truck total hours + costs truck total km	

Figure 14: Estimation total costs of transportation from customer to manufacturer

With the data provided above we are able to calculate whether or not it is viable for the manufacturers to take back, refurbish and resell furniture within the assumptions currently made. Below we will test the model by assuming that a customer who is situated 100km away from the factory has furniture with a new price of 50000 SEK which is no longer needed and qualifies for taking back.

Entering the value of 50000 SEK will give the following result on an estimating of the different costs.

	Based on	**Value**
Price of new products		**50000**
logistic costs	**12 % based on Logonbaltic**	**6000**
Warehousing costs	26 % of total logistic costs	1560
Costs of capital	5,38% of total logistic costs	322,8
Costs of obsoleteness & waste	8,67 % of total logistic costs	520,2
Insurance costs	1,62 % of total logistic costs	97,2
Packaging	7,33% of total logistic costs	439,8
Administration	11% of total logistic costs	660
Costs forward transport (refurbished to customer)	40 % of logistic costs	2400
Costs reverse transport (used furniture to manufacturer)	**40 % of logistic costs**	2400
reworking costs	**10 % based on assumptions**	**5000**
Selling price	**Assumption 50 % if new price**	**25000**
Compensation previous owner	**Assumption 15%**	**7500**
Potential Revenue		**4100**
Profit margin		**8,2**

Figure 15: Looking at the accepted costs of reverse transport, an estimation is given of 2400 SEK.

Calculating the expected actual costs for picking up the furniture from the customer who is situated 100km away, provides the following estimation:

Variable	Input	Based on
Distance (km)	100	
Costs per km in SEK	3,51	VTI
Costs total km both ways	702	
Hours of usage truck	3,666666667	75 km/h + 1 hour loading time
Costs of usage truck per hour	292,14	VTI
Costs using truck x hours	1071,18	
Total transport costs	1773,18	

Figure 16: Costs for transport customer towards manufacturer based on data LogonBaltic.

In this case we can see that the costs of collecting the furniture from the customer are estimated on 1773 SEK. Since these actual costs are lower than the reserved costs for transportation, we can see it is viable in this case for the manufacturer to collect, refurbish and resell the furniture.

Since the factors; value of the products and distance will change for every individual case, an overview is given in which easily can seen when the value of products is high enough to cover for the transportation costs for every distance. The maximum distance in km is set on 400 km, because the furniture should be able to be collected in one day in order to not complicate the simplified model of the costs for the truck too much. Since all major cities are within this radius of the majority of the furniture companies, the authors decided to limit the complexity of the model.

The figure below gives an overview of which value the products need to have in order to compensate for the transport costs per distance in km taking into account the assumptions as given above and gaining a profit margin of 8,2 %.

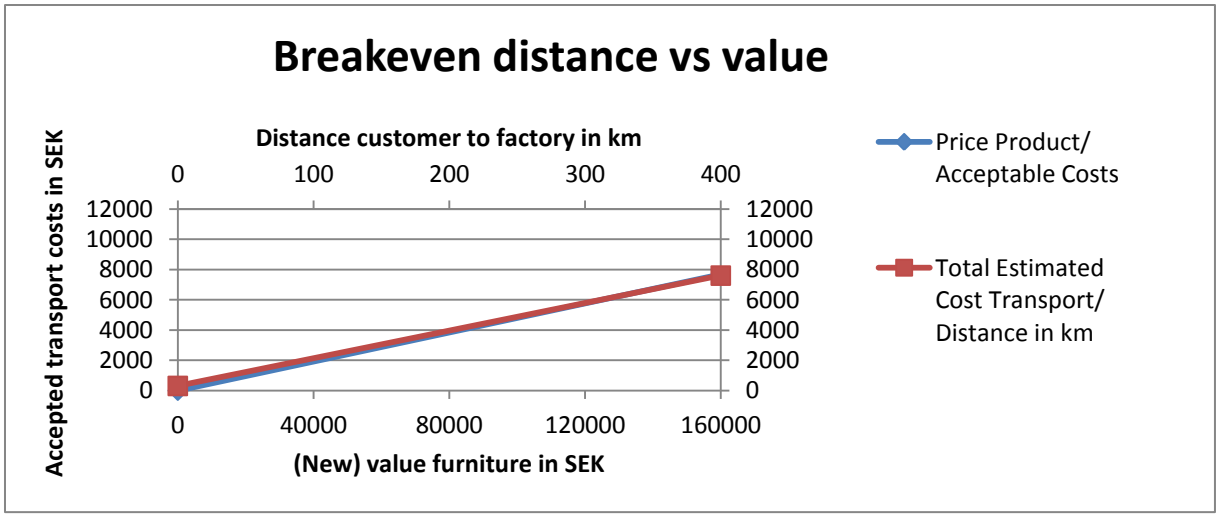

Figure 17: Breakeven distance vs. value

6.3 Scenario 2 Decentralized

The second model will be based on taking back the products after usage from the customers by the retailers. In this model the retailers will fulfill a temporary warehousing function. Just like in the first model the furniture will be shipped, refurbished and resold by the manufacturer. This scenario is also in line with the results of the interviews with the companies.

To see whether this scenario is viable the same data as in the previous model will be used. However, some additional cost aspects will be added to the model.
The first aspect that will be added is the compensation for retailers to fulfill a temporary warehousing function. The actual costs of temporary warehousing for the retailers is complicated to calculate, since it depends on how much space they have to spare and where the retailers are located. To simplify the model an assumption is made that the retailers will be given a compensation of 3 % from the new price of the furniture.

Next to this another factor is added, namely the costs of collecting the furniture from the customer, transporting it to the retailer and offloading the furniture at the retailer. Based on the interviews with the companies, as well as an interview with expert in the field of moving furniture (Niclas Gemfeldt, 2016), the authors have decided to make use of moving companies since they have experience with moving furniture. Several moving companies have been asked for a price-indication. Although the prices vary per region, an average of 550 SEK per hour including truck and driver has been found and will be used to base further calculations on. This is in line with the information as given on the website of Moveria AB, an

Internet-based service that helps people with their move (Moveria, 2016). For the calculations the assumption has been made that the customers are located near to the retailers, so a fixed costs of 550 SEK is used to base the costs of transportation on. We note here that the cost would likely be lower if crowdshipping service is used.

Contrary to the additional costs, the decentralized scenario provides some savings as well. These savings exist of the reduced frequency and thus cost of transportation from the customers towards the manufacturer. Instead of collecting and transporting the furniture from the individual customers, the transportation of the furniture towards the manufacturer can be bundled.

Taking into account the above mentioned calculations and assumptions, the profit margin for the retailer and the manufacturer can be calculated. The figure below provides an overview of the profit margins for various distances, based on 2 consolidation rides with a value of 30000SEK.

	Based on	Value	25 km	50 km	100km	150km	200km	300km	400km
Newprice of products		30000	60000	60000	60000	60000	60000	60000	60000
Selling price	50% of new price	0,5	30000	30000	30000	30000	30000	30000	30000
logistic costs	12 % Logonbaltic	0,12	7200	7200	7200	7200	7200	7200	7200
Costs reverse transport	Data VTI		765	1221	2133	3045	3957	5781	7605
Transport costs customer-retailer	tariff moving firms	650	1300	1300	1300	1300	1300	1300	1300
reworking costs	Assumption 10 %	0,1	6000	6000	6000	6000	6000	6000	6000
Compensation previous owner	Assumption 15%	0,15	9000	9000	9000	9000	9000	9000	9000
Profit Retailers	Assumption 3%	0,03	1800	1800	1800	1800	1800	1800	1800
Number of consolidation rides		2							
Profit manufacturer			3935	3479	2567	1655	743	-1081	-2905
Profit margin manufacturer			6,56	5,80	4,28	2,76	1,24	-1,80	-4,84
Profit Retailer & manufacturer			5735	5279	4367	3455	2543	719	-1105
Margin Retailer & manufacturer			9,56	8,80	7,28	5,76	4,24	1,20	-1,84

Figure 18: Framework decentralized scenario, # of consolidation rides is set on 2, new price of products is set on 30000 SEK.

Just like in the decentralized scenario, the value of the products and the distance towards the manufacturer are important variables. The third variable which has been added to the model is the number of consolidation rides from customers to the retailer. With this the number of customers that offer used furniture to the retailer is meant. With the model above we can conduct a sensitivity analysis to see how many consolidations rides are needed in order to make the decentralized scenario viable for pre-set distances of the retailer from the manufacturer for each value of the products. Below an example is given to test how many consolidation rides are needed with a fixed value of 20000 SEK to make the decentralized option viable for the fixed distances from the retailer to the manufacturer of 25, 50, 100, 150, 200, 300 and 400km.

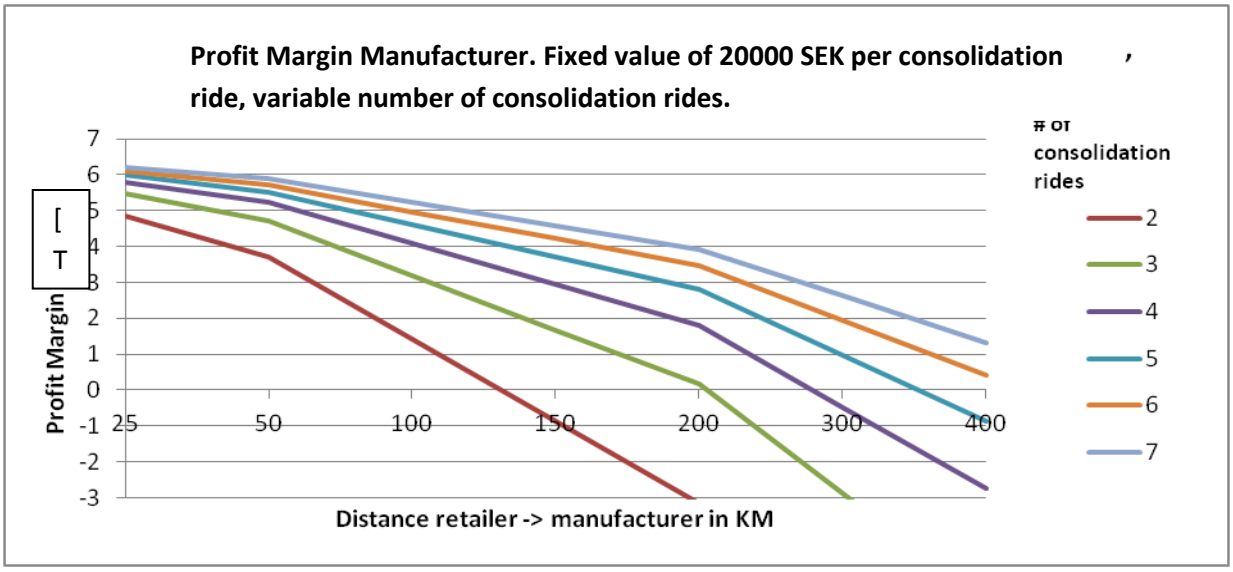

Figure 19: Profit margin Manufacturer, sensitivity analysis # consolidation rides

The results above indicates that a higher the number of consolidated rides towards the customer show a higher profit margin for the Manufacturer. The graph above shows that the higher the number of consolidation rides gets, the higher the distance from the Retailer towards the Manufacturer can be set, in order to still achieve a positive profit margin.

Next to just looking at the profit margin of the manufacturer, it might be interesting to see how the profit margin of the manufacturer combined with the profit margin of the retailer is affected by the number of consolidation rides. Below an overview is given of the combined profit margin of the retailer and the manufacturer based on the same values as above.

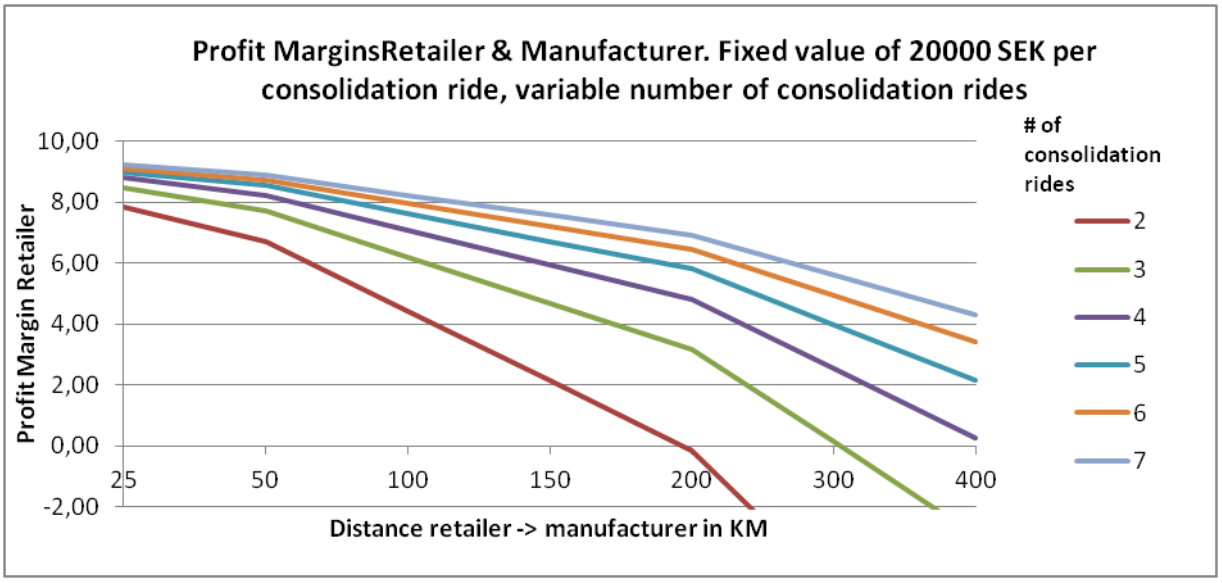

Figure 20: Profit margin Retailer & Manufacturer combined, sensitivity analysis # consolidation rides.

When comparing the two figures, it can be seen that the combined profit Margin of the retailer and the manufacturer is higher than just the profit margin of the manufacturer. It adds the 3% of profit margin for the retailer as assumed in the model. This outcome shows that looking at both the profit margin of the retailers and the manufacturer combined, higher distances can be covered without making an overall loss of for the retailer and manufacturer combined.

6.4 Comparing centralized and decentralized scenario

Based on the given calculations in the scenarios above, the profitability for every individual scenario can be calculated. However, it would be interesting to see, based on different inputs in the scenario's, which one is more profitable and where the break off points are situated. In order to do this the models have been combined and a comparison will be given below.

	A	B	C	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1				Central	Central	Central	Central	Central	Central	Central	Decentral	Decentral	Decentral	Decentral	Decentral	Decentral	Decentral
2		Based on	Value	25 km	50 km	100km	150km	200km	300km	400km	25 km	50 km	100km	150km	200km	300km	400km
3	Newprice of products		30000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
4	Selling price	50% of new price	0.5	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
5	logistic costs	12 % Logonbaltic	0.12	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200
6	Costs reverse transport	Data VTI		1530	2442	4266	6090	7914	11562	15210	765	1221	2133	3045	3957	5781	7605
7	Transport costs customer-retaile	tariff moving companies	650								1300	1300	1300	1300	1300	1300	1300
8	reworking costs	Assumption 10 %	0.1	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
9	Compensation previous owner	Assumption 15%	0.15	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
10	Profit Retailers	Assumption 3%	0.03								1800	1800	1800	1800	1800	1800	1800
11	Number of consolidation rides		2														
12	**Profit manufacturer**			6270	5358	3534	1710	-114	-3762	-7410	3935	3479	2567	1655	743	-1081	-2905
13	**Profit margin manufacturer**			10.45	8.93	5.89	2.85	-0.19	-6.27	-12.35	6.56	5.80	4.28	2.76	1.24	-1.80	-4.84
14																	
15	**Profit Retailer & manufacturer**			6270	5358	3534	1710	-114	-3762	-7410	5735	5279	4367	3455	2543	719	-1105
16	**Margin Retailer & manufacturer**			10.45	8.93	5.89	2.85	-0.19	-6.27	-12.35	9.56	8.80	7.28	5.76	4.24	1.20	-1.84

Figure 21: Framework decentralized & centralized scenario, # of consolidation rides is set on 2, new price of products is set on 30000 SEK.

When the individual companies adopt the assumptions made as explained in the secondary data, the formula as provided above has three different variables that can be adjusted. The distance, the number of consolidation rides, and the value of the products. The formula above enables us to conduct sensitivity analysis on different inputs. Below an example is given where we compare the centralized with the decentralized scenario. The output we are looking at is the profit margin of the manufacturer only. The number of consolidation transports is set on 2, the distance is set on certain fixed values as well and the value of the goods is the variable.

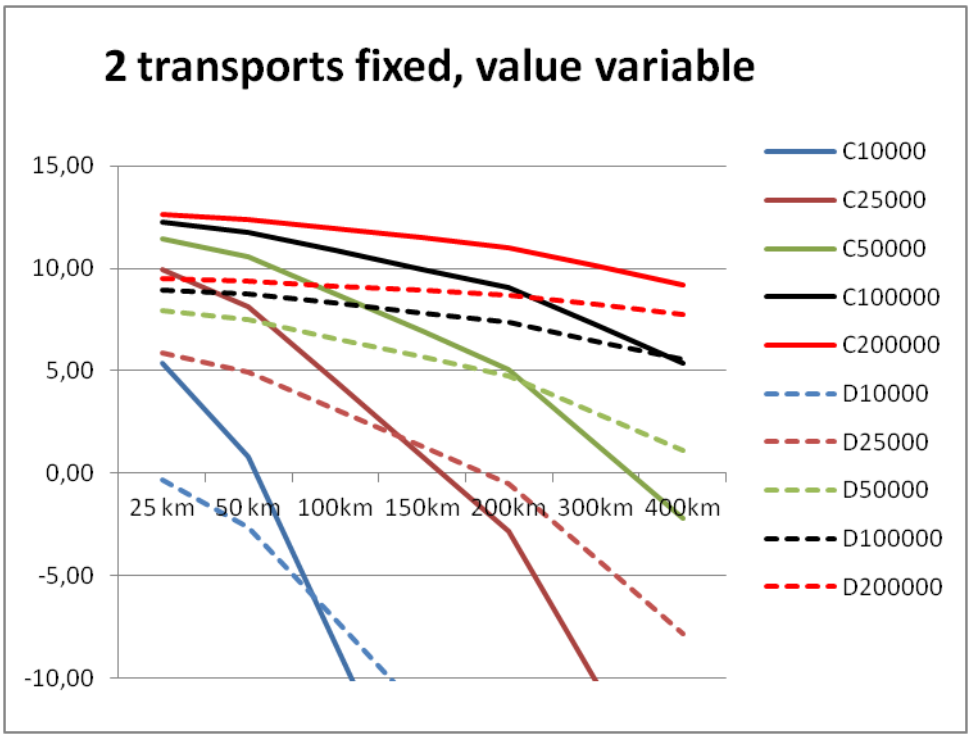

Figure 22: Profit margin Manufacturer only. Number of transportations fixed to 2, value of goods is variable C=Centralized, D=Decentralized.

Based on the figure above, the most profitable decision between scenario one and two can be made from the point of view of the manufacturers. The data shows that with a fixed number of 2 consolidation transports, regardless of the value of the products, the centralized scenario has the preference above the decentralized scenario. When the distance from the manufacturer to the customer increases, the decentralized scenario

becomes more appealing. When the turning point is achieved depends on the value of the products.

Apart from just looking at the profit margin for the Manufacturer, an analysis can be done at which point which scenario is more favorable for the manufacturer and retailer combined. The same variables have been used as in the figure above, but the profit margin of the Manufacturer and the Retailer combined is used to see at which point a decentralized scenario becomes more favorable.

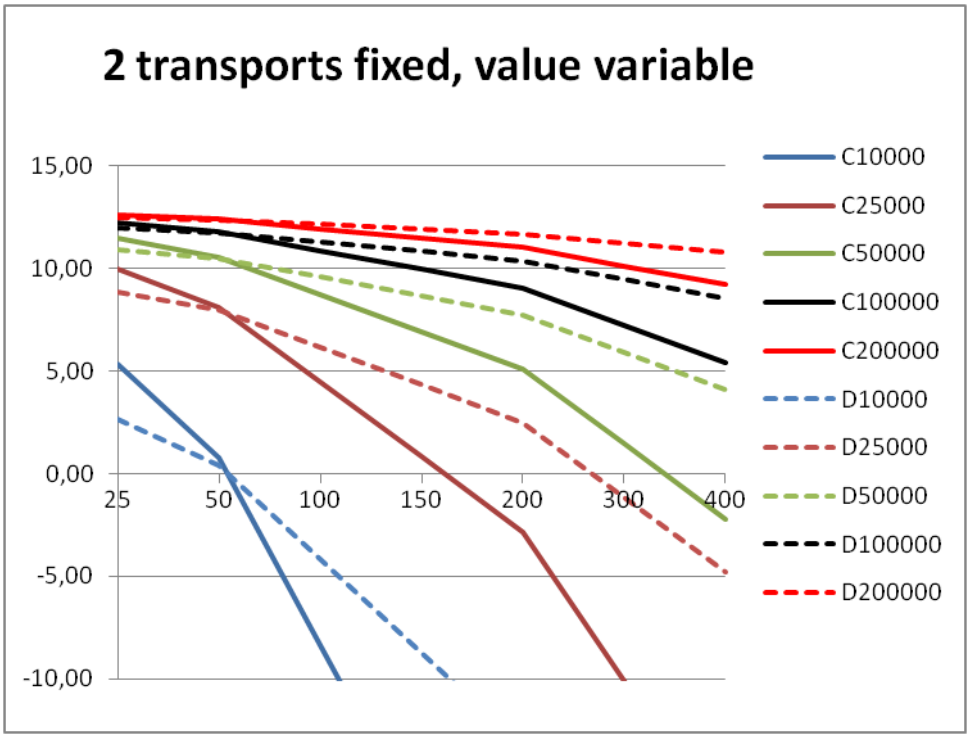

Figure 23: Comparison of centralized and decentralized scenario with the profit margin of retailer and manufacturer combined. C=centralized, D=Decentralized.

The figure above shows that the turning point at which the decentralized scenario becomes more favorable is reached at shorter distances. This is logical since the decentralized options remain the same, while the centralized options increase with the 3% that have been taking into account in the model as a compensation for the retailers. The reason why this comparison has been included in the report is the fact that some manufacturers have their own retail-outlets. This comparison could help those companies obtaining the maximum profit margin for the retailer and manufacturer combined and may prevent them from sub optimizing.

In order to clarify the findings an additional figure is added to show that the most profitable scenario changes when one of the variables are altered. In figure 24 the number of consolidation transports have been increased to 4, compared to 2 in figure 22. Both figures show the points of intersection for different values of the furniture, at which distance the decentralized scenario yields a higher profit margin for the manufacturer.

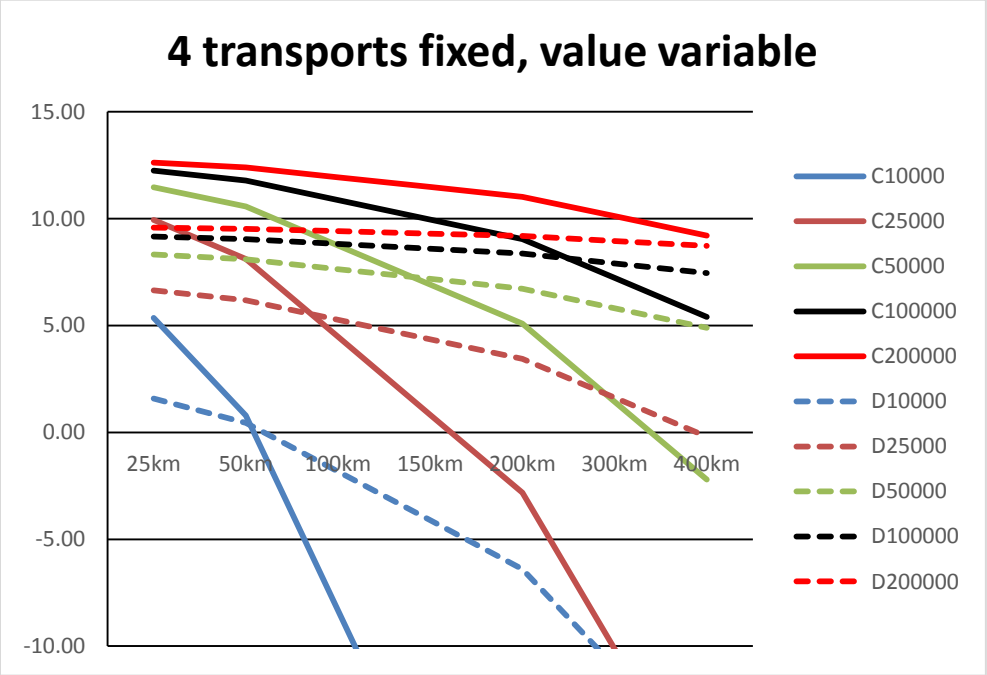

Figure 24: Comparison decentralized and centralized scenario based on the profit margin manufacturer.

Comparing figure 22 and figure 24 with each other, it can be seen that a higher number of consolidation transports leads to a preference of the decentralized scenario at shorter distances.

6.5 Discussion

The data analysis and displays above have been carried out in order to answer the two hypotheses as formed in the Methodology:

H1: Recovering used furniture directly from the customers, transporting them to the manufacturer, refurbishing and reselling them is viable in the current situation.
H2: Recovering used furniture from the customers, storing them temporary at the retailers, bundling the transport towards the manufacturer, refurbishing and reselling them is viable for the Manufacturer in the current situation.

Based on the data above, the authors conclude that in the current situation recovering used furniture through both the manufacturers and through the retailers can be viable. However, there are also situations in which the hypotheses have to be answered negative. No clear answer on the hypotheses can be formulated and the outcome depends on the variables as mentioned above, distance, price of products & the number of consolidation rides. However, the model above provides a clear indication in which cases it is viable for Manufacturers to engage in a circular flow and in which cases it is not. Based on the model above a third hypothesis can be added:

H3: Recovering used furniture from the customers, storing them temporary at the retailers, bundling the transport towards the manufacturer, refurbishing and reselling them is more profitable for the manufacturers than recovering used furniture directly from the customers, transporting them to the manufacturer, refurbishing and reselling them in the current situation.

The same answer to the first 2 hypotheses can be found here; it depends on the variables whether the hypothesis has to be accepted or rejected.

Two more hypotheses can be added by looking at the profit margin of the Manufacturer only, or the profit margin of the Manufacturer and the Retailer together.

H4: Recovering used furniture from the customers, storing them temporary at the retailers, bundling the transport towards the manufacturer, refurbishing and reselling them is viable for the total result of the Manufacturer and retailer together in the current situation.

H5: Recovering used furniture from the customers, storing them temporary at the retailers, bundling the transport towards the manufacturer, refurbishing and reselling them is more profitable for the manufacturers and retailers combined, than recovering used furniture directly from the customers, transporting them to the manufacturer, refurbishing and reselling them for the manufacturers and retailers combined in the current situation.

Just like the first three hypotheses there is no clear yes or no answer for H4 and H5 and it strongly depends on the distance, the value of the products and the number of consolidation rides.

The result reached by the authors is in line with previous research made by Besch (2005) and Clarke-Sather (2006) as both authors mentioned that recovering products through decentralized system is feasible. However, it differs from what was written in the literature about the feasibility of recovering products through centralized systems. For example, the result of this study differs with what Clarke-Sather (2006) mentioned about some of the American furniture producers such as Steelcase, Haworth and Herman Miller which were successful in their furniture remanufacturing business because they owned independent decentralized remanufacturing facilities with low volumes of remanufactured products. When these companies decided to shift to centralized facilities working with larger volumes, their remanufacturing business deteriorated sharply and they had to stop furniture remanufacturing. It appears that those furniture companies were not capable to remanufacture anymore as they could not handle the larger volumes especially with the increased transportation cost, which made the remanufacturing business financially unviable for them after the centralization of their facilities. Obviously, the financial success of a remanufacturing business is determined to some extent by the decisions of centralizing or decentralizing service facilities. Therefore, based on the calculations made by the authors, each company can decide on the degree of centralization or decentralization according to their fixed and variable costs and the whether or not they own the retailers.

7. Conclusion

Furniture which is sent to landfills nowadays has a remaining value which is wasted, therefore it is the time for furniture companies to consider reusing and remanufacturing furniture to recapture the remaining value in the furniture and to lower the environmental impact generated by new productions and the use of new raw materials. Recapturing the remaining value in used furniture would also be appealing to customers as they can refurbish their furniture (e.g. different fabric/color) and use it for a few more years. This is cheaper compared to buying new furniture. The logistic issues which Swedish furniture companies might encounter when engaging into remanufacturing and reselling of furniture have been analyzed and discussed. In this report an overview of the various costs of logistics that have to be taken into account have been discussed and estimations have been provided. Efficient logistics is very crucial in order to create viable circular flows of furniture and this can be achieved in various ways, depending on the individual situation of the companies.

Based on literature and the interviews, the authors have used two different scenarios in order to provide estimations for the companies to choose the optimal solution of engaging in circular flows of goods, namely a centralized and a decentralized scenario. With the help of the models the best option for taking back furniture to the manufacturer can be calculated based on the current state of the supply chains.

Referring back to the research purpose and questions, the authors believe that Swedish furniture companies have potentials in engaging in remanufacturing of furniture. In this report it is shown that furniture companies can create a new stream of revenue by remanufacturing and refurbishing furniture. As the calculations in this research show, companies should determine the optimal solution based on the distance of the customers to the manufacturers and the value of the products. No clear answer to the hypotheses could be formulated, due to the various variables involved in the decision making. However, a clear overview of the expected logistical costs and a guideline to support the decision on how to organize the reverse logistics for individual cases has been provided.

8. Future research

This paper has mainly been focusing on the logistic aspects and further research on environmental improvements in remanufacturing furniture is still required. Next to this the marketing aspect and the market conditions of selling second hand furniture has not been taken into account in this research. In order to gain more insight in the viability of the different scenario's further research is required.

Furthermore this paper reasons from the current state of the supply chains and the current production processes. In order to get a complete picture for the future, more research about the effect of modular designs of furniture on transportation will be needed. Although centralization and decentralization of remanufacturing facilities were considered in this paper, more research is still required about the optimal location for service facilities. This is because of the fact this report is based only the current locations of the various production facilities. The decentralization of production facilities might even result in higher profit margins.

Next to this the usage of crowd shipping has been mentioned in this report as an alternative to retrieve the used furniture. Due to the nature of furniture, this might not be easy to implement, but considering the current conditions in the transportation industry this deservers further research as well.

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