Restructuring the Reverse Supply Chain: Challenges and Opportunities Within the Automotive Industry

Master's thesis in Supply Chain Management

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Summary

Reverse supply chain management has gained increased attention in recent years, much due to its close relationship with circular economies. In circular economies, resources are used to recycle, reduce, and reuse materials. To perform this, a reverse supply chain is needed. This thesis will investigate how companies can structure their reverse supply chain to reach both financial and environmental targets. To analyze how the focal company works today and how they could work in the future, the ARA-model has been used. The ARA-model consists of analyzing activities, resources, and actors respectively and the relations between the three. To analyze the problem, two research questions were defined with focus on resource utilization and activity coordination. Based on the analysis made using the ARA-model, three improvement areas where identified. These are supply chain structure, supply chain visibility and goals and KPI's. Within these areas, recommendations were given to improve both resource utilization and activity coordination.

Key words: Reverse supply chain management, Automotive industry, recycling, Supply chain management.

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1 Introduction

In this chapter, an introduction to the research area of this thesis work conducted in collaboration with Volvo Service Market Logistics is presented. Initially, a background of the topic of reverse supply chain management is given along with some of the factors highlighting the current relevance of the topic. Following this, an introduction to the automotive aftermarket is given in which the focal company of the thesis operates. Furthermore, a presentation of the case company is provided as well as their current situation which has been the point of departure in this project. Finally, the aim and delimitations of the project are presented.

1.1 Introduction to reverse supply chain management

Reverse supply chain management refers to the execution of activities involved in managing the return flow of goods and information from the point of usage to locations further upstream the supply chain. These activities include production planning, inventory management and transportation as well as the exchange of information and coordination between actors in a supply chain network (Gupta, 2013). In other words, reverse logistics can be described as the planning of goods that are moving "backwards" through the supply chain given that most of the product flows are traveling in the opposite direction (Bernon & Cullen, 2007). Reverse logistics and reverse supply chain management will be used interchangeably throughout the thesis. Although reverse logistics in principle is an inverted form of forward logistics, the management and execution of the two concepts have some major differences. Firstly, the forward flow of goods is far more predictable than the return flow since the level of certainty regarding the volume and location of the demand for returns is significantly lower. Moreover, with forward logistics, the goods flows are one-to-many as opposed to in reverse logistics where the flows are many-to-one. This means that instead of distributing goods from one location to several different locations, the goods are sent from multiple locations to one location. This in turn leads to a decreased ability to secure efficient and standardized processes for the goods handling as well as the necessary equipment, packaging, tracking etc. required to ensure a seamless distribution (Gupta, 2013).

Historically, forward logistics have been the main focus for companies since the competitiveness of a firm's distribution has been seen as their ability to deliver goods on time and avoid out-of-stock situations. However, reverse logistics have gained increased attention in recent years, much due to its close relationship with circular economies (Cricelli et al., 2021; Gupta, 2013). In circular economies, resources are used according to the 3R strategy which aims to recycle, reduce, and reuse materials (Del Giudice et al., 2020). Increased circularity in supply chains can be achieved by forming open- or closed-loop chains as opposed to linear chains. Closed-loop chains mean that products are sent backwards through the supply chain from their point of use to the point of origin at the end of their life span to be remanufactured and reintroduced for future use. Open-loop chains instead refer to products that cannot be remanufactured but instead are recycled to capture the remaining value of materials that can be used for other purposes (Cricelli et al., 2021).

Efficient and effective reverse supply chain management can reap various benefits for companies such as improved financial and environmental performance as well as increased customer satisfaction (Cricelli et al., 2021; Adabayo, 2022). Increasing the reusability of products and materials through remanufacturing and recycling allows for an extended product life cycle in comparison to the more traditional linear supply chain approach. Here, products and materials remain in the supply chain loop for an extended time before they are disposed of. This means that less raw materials and other resources are exploited during the production processes than when producing new products. This has both environmental and economic consequences as the extraction of materials, energy and other resources used in production pose a major threat to the environment while companies can simultaneously reduce costs by making use of already manufactured components (Cricelli et al., 2021). Moreover, customers today are becoming increasingly demanding in terms of return policies and ease of processes, meaning that companies can gain increased customer attraction and retention by improving the return processes of their service offering (Adabayo, 2022). Thus, the reverse supply chain concept is not merely of interest for society but also for companies that are operating in line with it along with their stakeholders.

1.2 Empirical context

The automotive aftermarket serves to support operating vehicles after their initial point of sale until the end of their life span. Activities included here are repair and maintenance work on vehicles as well as the manufacturing and distribution of spare parts (Hsieh & Zhang, 2022; Cohen et al., 2006). The supply of spare parts and maintenance is crucial for both automotive manufacturers, as well as for their customers. Spare part sales often constitute a large portion of the profits generated by automotive OEMs, thus making them a valuable contributor to the profitability of companies in the industry (Cohen et al., 2006). On the customer side, a reliable availability of spare parts is crucial to reduce the risk of facing large expenses due to disrupted operations caused by breakdowns (Pfohl, 2022). A lack of available products within the aftermarket segment therefore gives rise to lost profits and decreased customer satisfaction, as well as lost vehicle uptime and increased costs. The spare parts market is thus characterized by a high pressure on quick and reliable deliverability. At the same time, the demand for aftermarket products is subject to a high degree of variation and uncertainty, making it a highly complex market from a logistical point of view (Cohen et al., 2006).

Along with other industries, the automotive aftermarket has also experienced previously mentioned sustainability related trends such as circularity with an increased attention pointed towards concepts like remanufacturing and recycling (Buruzs & Torma, 2017). The market is also experiencing other emerging trends such as e-commerce markets for spare parts and an increased focus on providing seamless and easy-to-use services for customers. This has implications for the way logistics processes need to be designed, and incumbent companies need to adapt in order not to lose market share to new entrants.

Volvo Group, the focal company of this study, is a multinational manufacturing company with its headquarters in Gothenburg, Sweden. The company has a presence in 190 countries and over 100 000 employees. The company has multiple brands such as Volvo Trucks, Volvo Penta, Volvo Construction Equipment(CE), Volvo Buses as well as Volvo Energy to mention a few. They also have acquired many companies such as UD trucks and Renault trucks and take part in many joint ventures. They are active in many industries such as marine and industrial engines, trucks, buses, and construction equipment. An organization chart of Volvo Group is presented in Figure 1 below.

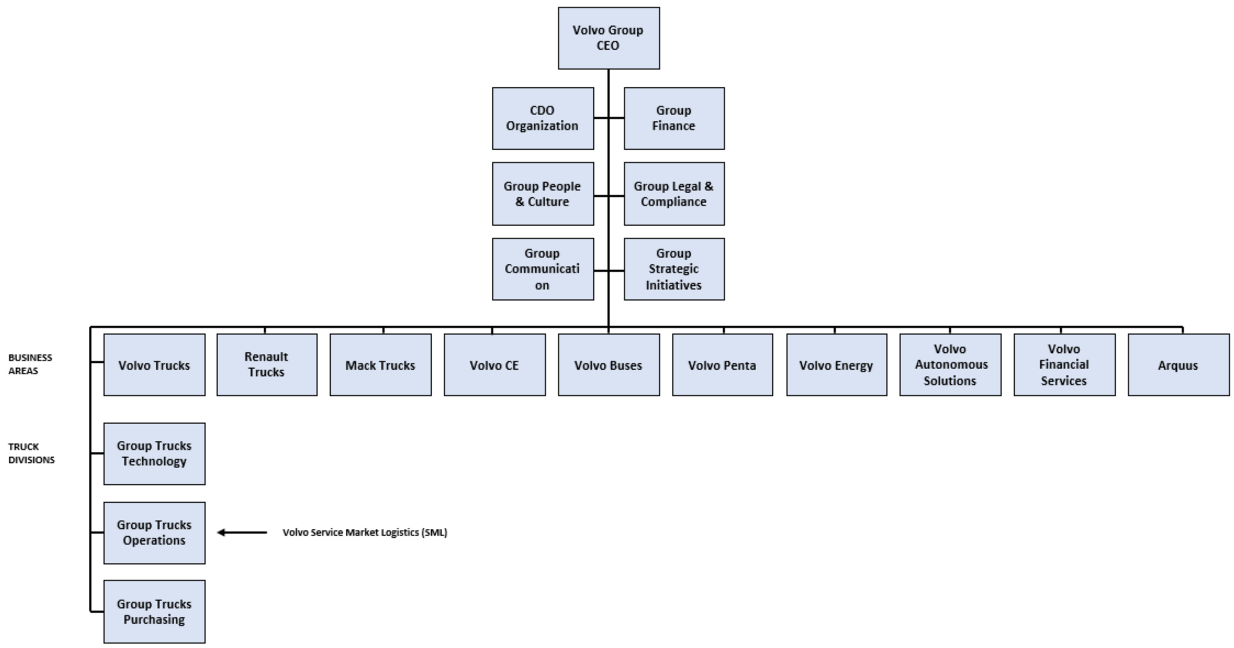

Figure 1. Organization chart of Volvo Group.

In addition to the above-mentioned brands, Volvo Group also has subsidiary companies mainly working with managing the operations of these companies such as Volvo Group Technology and Purchasing, Volvo Logistics as well as Volvo Service Market Logistics (henceforth referred to as Volvo SML). The focus in this thesis will specifically be on a division of Volvo SML called *Transport Flow Optimization and Footprint Design*. Volvo SML is a part of the Volvo Group Trucks Operations. This division focuses on ensuring that spare parts are delivered on time, both to and from its customers and third-party suppliers. In addition to this, the overall goal of the division is to analyze and work with sustainability questions to reach Volvo's long-term goals for emission and circularity.

1.3 Problem description

Volvo SML provides logistics aftermarket services for the different Volvo companies. The main goal for Volvo SML is to secure high deliverability and service levels to Volvo's customers to generate as high uptime for the end customers' products as possible. This service-driven business model is a key factor as the aftermarket sales constitute a large portion of the company's profits and since Volvo Group's overall aim has turned more towards sustainability and uptime. One of the largest sources of negative environmental impact in Volvo Group's supply chain comes from the product manufacturing. To reduce this impact as much as possible and increase the circularity of their supply chain, the company aims to extend the life cycles of products and materials by putting more efforts on recycling and remanufacturing products. Reducing the emissions and the resource consumption in the manufacturing by reworking already produced products that have reached the end of their life span has therefore been an important step towards reducing the company's environmental footprint.

However, increasing the degree of products and materials being recycled and remanufactured leads to an increase in the return flow of products from dealers to the remanufacturing/recycling plants. This in turn leads to an overall increase in the transport demand. Hence, achieving a higher performing supply chain from an environmental perspective further increases the need for efficient logistics processes which makes Volvo SML an important actor in the Volvo Group's transition towards a more sustainable company. Maintaining low return rates has been seen as a key factor for cost reduction by eliminating unnecessary transports and thereby lowering the overall transport costs. With the mentioned increase in environmental awareness as well as higher pressure from customers on efficient return processes, returns have recently been regarded as more of a competitive advantage rather than a necessary evil. Despite this, the return flow of the company's supply chain has been rather overlooked, which has led to a consensus within the organization that the reverse supply chain needs improvement.

1.4 Aim

The purpose of this thesis is to analyze Volvo SML's current reverse supply chain and their current ways of working. This will be done by looking at the physical flow of goods along with the financial and informational flows. Furthermore, a set of recommendations will be provided for how Volvo SML can address issues and identified areas of improvement in their current reverse supply chain.

1.5 Scope and Delimitations

Volvo SML has a global footprint, and their reverse supply chain consists of many different processes, making it a complex matter to analyze. To be able to make an in-depth analysis and extract some valuable insights with respect to the time duration of this research project, some delimitations have been made. Firstly, the project has been narrowed down to focus on the Northern European part of the company's distribution system. This geographical region is internally referred to as EMEA North, with focus on the Swedish operations. The analyses will thus not address the company's operations in other parts of the world. However, the findings in this thesis can be used as a point of departure for similar studies in other geographical areas.

Moreover, the evaluation of the company's reverse supply chain will focus on the flows in the system, i.e., how goods, information and money is transferred between different entities within the network. Additionally, the focus will only be on the parts of the reverse supply chain which are in the scope of Volvo SML, thus excluding points beyond the manufacturer upstream, and beyond the dealer downstream the reverse supply chain.

2. Theory

In this section the theoretical framework is presented. The main topics that will be covered are reverse supply chain management, remanufacturing, return processes and physical distribution. Furthermore, in the end of the chapter a network approach to reverse supply chain management is outlined.

2.1 Reverse supply chain management

According to Jayant et al. (2012) reverse logistics is the return flow of goods from the downstream of the supply chain, e.g., end customer to manufacturer, with the purpose of either remanufacturing, returning goods or overstocking. This requires actions from both the manufacturer of the products as well as the customers. To increase the efficiency of the remanufacturing, manufacturers can ensure that their products are easy to assemble and reassemble. This makes the dismantling of products easier and opens for the possibility to use a modularized approach that supports remanufacturing. One of the most critical aspects of reverse supply chain management (R-SCM) is the cost. There are several methods for how companies can reduce the costs of their reverse supply chains. On such method is to make sure that the distribution centers in the reverse supply chain are strategically located. Even though handling costs for remanufactured products are high, firms can capture other value from these products. One of the benefits with these products is that remanufacturing both reduces the material cost and material demand by using already extracted resources. Additionally, remanufacturing can lead to repetitive purchases by giving customers incentives, e.g., in the form of reduced prices when returning their used products before purchasing a new one.

Jayant et al. (2012) argues that there are three different types of returns:

- **End-of-life returns:** These returns are made to achieve a higher degree of sustainability by disassembling and recycling products at the end of its lifespan. The initiative of these returns is normally due to an agreed contract between seller and customer.
- **End-of-use-returns:** After using the product, the customer can purchase a new one or a remanufactured one. Alternatively, the used product can either be remanufactured or sold to the aftermarket.

- **Commercial returns:** Commercial returns are made when a customer experiences a problem with a product. Reasons for these returns include product recalls, warranty claims, and that products are damaged during transport.

Jayant et al. (2012) state that the cost of R-SCM is mainly driven by transportation. This depends on variability of products, product quantities, and material handling. One way to reduce transport costs is to have consolidation centers to enable consolidation and generate economies of scale. The success of reverse logistics is dependent on the distance between the resellers and the distribution centers. In the automotive industry, exchange of products is commonly used, where a remanufactured product is only sold once a used product is returned. Therefore, the customer acts both as a customer, but also a supplier for the remanufacturing process. Companies often use a cost reduction program if the customer is willing to send back the product after its first part of the life cycle.

2.1.1 Return process

Santos et al. (2022) argue that the automotive industry needs to shift its focus from primarily financial performance to sustainability performance due to changes in the business environment. This change will have a significant impact on the interfaces between different actors in the reverse supply chain, particularly regarding an increase in returned products between actors. The automotive industry is adapting their activities to reduce energy consumption and emissions, and this shift is reflected in the transition from an open-looped supply chain to a closed-loop supply chain. The closed-looped supply chain aims to create value beyond the initial use of the product by incorporating reverse logistics where used products are either repaired or recycled. After remanufactured, the products are reintroduced to the outbound flow. An example of a closed-loop supply chain is presented in Figure 3 below.

In an open loop supply chain, the products are either scrapped or remanufactured by external companies. By using a closed-loop supply chain, firms can generate profit while reducing material use and emissions within the firm. The profit comes from reselling products that has already been produced. The reduction in material is based on that little or no new material is needed to reproduce a well-functioning product, this also reduces the emission compared to making a new product.

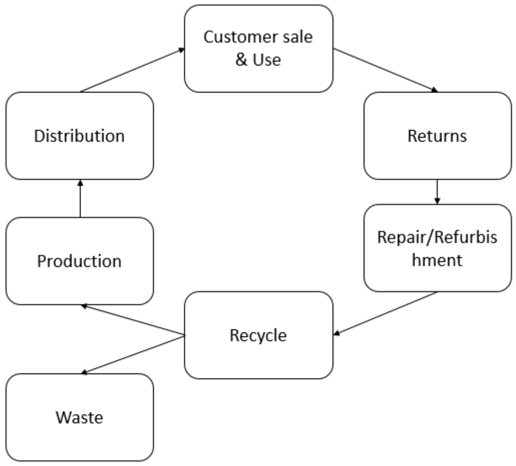

Figure 3. Visualization of a closed-loop supply chain.

There are numerous reasons that may lead to a customer request to return a product, such as an incorrect product being dispatched, the product failing to meet desired requirements, or the need for the product to be remanufactured after prior usage. As the sustainability focus has increased, Zalani et al. (2017) argue that there has been a rise in the willingness to return products as opposed to scrap them. In addition to this, research shows that waste reduction improved financial performance. One limitation with the return process is that most firms have designed their flow with the outbound products in mind, with a rather limited focus on returns. Because of this, the flow is not optimized to handle large return volumes. Furthermore, the awareness of return processes within top management has increased, which has led to that they find it important to maintain good relationships with stakeholders and/or customers.

Santos et al (2022) suggests a few ways to address challenges within reverse supply chain management such as, knowledge, time to change and willingness to change. The first one is to develop partnerships and do research on the topic. Research could be done in collaboration with universities or research centers. This research can be used to gain awareness about what knowledge is lacking within the organization. By finding out what knowledge or competences are missing, actions can be taken to address the problems, either internally within the organization, or with help from external people. The second option is related to innovation. Innovation is seen as one of the aspects that are unavoidable to develop a better return process and become more sustainable. The innovation process can be done through a trial-and-error method and the use of continuous improvements to become better one step at a time. The authors argue that it is unavoidable to make initial mistakes when developing solutions that can lead to a better return process. The third option is through technological development. The way companies within the automotive industries have developed their products is through small stepwise developments, and this could be used in all different processes of the organizations.

2.1.2 Remanufacturing

According to Daniel et al. (2001) corporations try to create sustainable products to establish and follow corporate social responsibility. This can conflict with the rationality of a firm to generate returns to create shareholder value. Remanufacturing of products is a sustainable way to recover products already used by end-customers so that customers can reuse them. This process consists of value-adding-remanufacturing such as traditional remanufacturing as well as recycling of materials. These activities decrease material use, both in terms of materials and energy for production and mining. Toffel (2004) explains that firms using this can benefit both from cost reductions within production, meeting customer demands as well as showing an image of environmental responsibility.

According to Daniel et al. (2001), there are many factors that increase the complexity of return flows compared to outbound flows. For instance, inventory management, planning materials and capacity requirements make the return flow as well as remanufacturing complicated processes to operate. The increased variability of both products and volumes makes reverse logistics a complex matter and expensive in terms of staff, system control, logistics and quality. Toffel (2004) argues that one way to reduce the complexity is to offer financial incentives to customers who return products of a certain quality. The extra complexity with returned products creates a greater workload than just recycling a product. It requires space and staff to sort, inspect and categorize the products. There will also be great variation in terms of routing, both for the inbound and outbound flow. Products originate from different places, and depending on the category of the product, they should be sent to different remanufacturing locations, or directly to recycling. Consequently, operational costs tend to increase.

Daniel et al. (2001) mention two incentives for companies to start remanufacturing their products, either driven by legislation or the market. Legislations make the companies responsible for the returns of products. Market driven incentives are based on that the companies see a value adding activity that they can make financial gain from. To motivate end-users to return their end products, firms use financial incentives for the consumer to return the products to the producer. Mandatory legislation that requires end customers to return products and producers to recycle or remanufacture them can create entry barrier for firms. Such legislation can increase costs and the need for awareness of supply chain operations.

2.2 Physical distribution

2.2.1 Supply chain mapping

According to MacCarthy et al. (2022), supply chain mapping is a useful tool for gaining an understanding about the design of a supply chain as well as for investigating the impact the design has on their planning, management, and control processes. The knowledge gained from mapping a supply chain can also be of great use for assessing the performance of the supply chain in order to deploy strategic actions towards increasing its effectiveness. Supply chain maps can be used to create a simplified representation of a real-world supply chain with “both visualization and information about key features”. The mapping aims to present this information in an easily understandable manner while at the same time providing enough depth of the information to be used for further analysis.

MacCarthy et al. (2022) state that a supply chain map consists of links and nodes which are connected and together form the supply chain structure. Lumsden (2011) describe the nodes in a physical distribution system as points between which physical products are moved. These nodes serve as locations where products have supply or demand and can represent different things depending on the system design, such as warehouses or producing facilities. At the nodes, different activities are performed that are part of the distribution system. These activities include consolidation, loading, sorting and production. The nodes have links between them which connect them together. Lumsden (2011) describes that the links that connect the nodes represent the movement of goods between them, i.e., a transport. The transport activity can be performed in different ways and with different modes of transport. MacCarthy et al. (2022) state that links can additionally represent the information and financial flow between nodes. When looking at a supply chain map, the information and financial flows typically travel in both directions between nodes, while the physical flow travels either upstream or downstream depending on if it is mapped from the perspective of forward or reverse logistics. A visualization of a physical distribution system is presented in Figure 4 below.

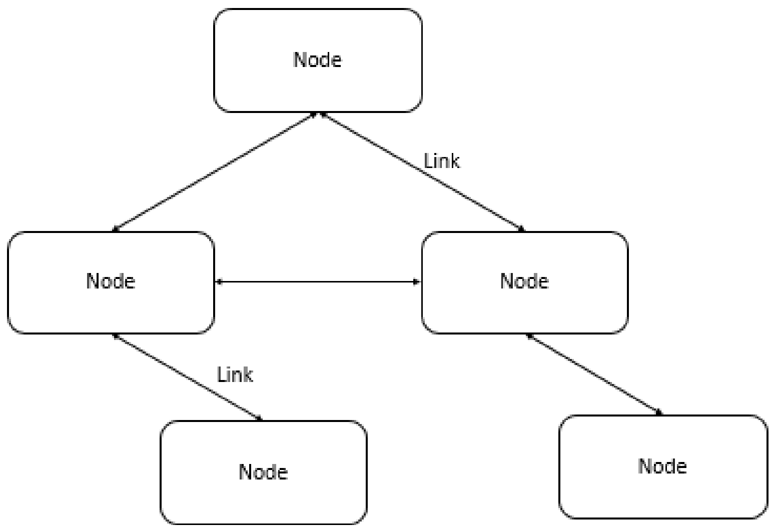

Figure 4. Nodes and links in a physical distribution system.

Considering the granularity of a supply chain map, MacCarthy et al. (2022) proposes a hierarchy of maps ranging from a macro-perspective (global value chain maps) to a micro-perspective (process maps). Within this hierarchy, they define supply chain maps as being in the middle of the range. In contrast to global value chains and supply network maps which capture the full interplay of all actors operating within large networks, supply chain maps take a narrower point of view on a focal firm and its interactions with other entities in a subset of the entire supply network. This gives the ability to map this subset of the network as more of a linear supply chain and provide a higher level of detail on the processes included.

2.2.2 Physical flow

Li Leng & Zailani (2012) state that the product flow is the center piece of a well-established supply chain. One way to improve a supply chain process is therefore to reorganize the physical flow. The physical flow includes the entire process from raw material to finished goods. The physical flow generally moves from raw material to the end-customer, which is significant for a forward flow. Childerhouse & Denis (2003) argues that for a reverse flow, for instance during a product return, the physical flow starts from the customer and ends at remanufacturing. To improve the physical flow, companies should avoid having conflicting objectives within their reverse supply chain. One way to achieve this, could be to not use one strategy for different markets in the physical flow. By separating the physical flows, it is easier to fulfill the objectives of each one than by analyzing them as one flow. The authors state that one way to reach better performance in the supply chain is to simplify the physical flow.

2.2.3 Information flow

Li Leng & Zailani (2012) argue that most organizations consider the flow of relevant and up-to-date information to be as important as the physical flow. Sharing information is a substantial part of the supply chain that mirrors the cooperability between the different parts of the chain. The information flow is based on sharing information with the other parties in the chain. Data sharing between different companies includes being to be able access information in each other's systems. Based on this, it should be possible to track a product through the entire chain. Valuable types of information included in the information flow are order status and inventory status among others. Each supply chain has its own design and requires different kinds of information. The degree of information that companies have access to in their supply chains also differs. This implies that information about the full the supply chain is not always available to all actors. This isn't always a sign of poor information sharing; it may be deliberately designed by actors to avoid sharing valuable information.

Global companies have diverse process methods, materials, resources, and information in various regions. Therefore, it is critical for them to ensure that the information flow functions effectively across different regions and promotes collaboration. It is also essential that all parts of the company have appropriate systems that can facilitate cooperation and support communication channels that align with the supply chain needs. Effective communication channels have a strong impact on the supply chain performance by enabling faster decision-making and the ability to act to sudden changes.

Tang et al. (2010) argue that the information flow can be seen as the link between the product flow and the financial flow. Issues related to the information flow contain accuracy, information sharing and security. Value adding information flows contain order fulfillment, changes in capacity, demand, and inventory. Inaccuracy of information can be related to either the efficiency or the access to data. Inaccurate data will have great impact on the decisions made in the supply chain and lack of access to data create invisibility and make decision processes more complex. Collaborating with external actors make the information sharing process a necessity but it is also complex since it increases the risk of allowing competitors to receive valuable information and is therefore a security risk.

2.2.4 Financial flow

Pfohl et al. (2009) define the financial flow within supply chain management as the financial supply chain. Besides analyzing the efficiency of the product flow, they discuss the cash management. The purpose of analyzing the financial flow is to enable collaboration across company borders. This process requires a smooth information flow. It also acts to keep customers satisfied by ensuring that they have money in the flow when they could use it better somewhere else. It is also important to have knowledge of the laws and regulations of the countries a company is active in, such as taxes, tariffs, and VATs.

2.2.5 Physical distribution strategies

Cook et al. (1985) state that some firms use different independent departments to manage their physical distribution, called a non-integrated system. There are also companies that try to develop a distribution strategy on an international level based on integration. The benefit with an integrative distribution system is that it generates better efficiency and effectiveness compared to a non-integrated system. One situation, where a non-integrated strategy could be beneficial is when there is great difference between the customer requirements between different markets. However, an integrated physical distribution planning can also support different customer requirements.

As an example, Cook et al. (1985) present a case where two different markets demand different lead time, and the distribution is planned for each separate market but located on the same continent (non-integrated). Thus, there will be two different shipments. The other option is to use an integrated approach, where the shipments are consolidated into one shipment. In that case, one of the orders will be ready earlier than the other and is therefore needed to be held in a trade zone before the consolidated delivery can be made in alignment with the customer request. If the costs for keeping the product in the trade zone is lower than the one for sending two different shipments, the integrated approach is beneficial economically without reducing customer satisfaction.

Designing a strategy where each separate country has their own distribution system also makes it difficult to evaluate the different services for the respective regions, as well as the cost trade-offs compared to using an integrated approach. Costs that should be taken into consideration when analyzing one region for instance be legal or economical, are called *trade barrier costs*. As an example, goods planned to go to UK or Switzerland may not have the same transport requirements as a transport to Belgium or Sweden.

One way to increase the efficiency of a physical distribution strategy could be to use a total systems logic, consisting of total cost analysis and the systems approach. The total cost analysis compares different distribution designs and its relative cost trade-offs compared to the current one. The systems logic can be used to analyze the entire international physical distribution system's performance and strategy instead of looking at separate segments such as brands, divisions, or products. The physical distribution planning should be used on a global level. It works for all sizes of companies and could be applied to companies with different structures and physical distribution complexity.

2.3 Supply Chain Sustainability

Seuring & Müller (2008) state that producing companies often have different processes globally. Furthermore, the different companies, customers and external suppliers are linked by products, information, and financial flows. Besides the product responsibility of companies in a supply chain, there is also a social and environmental responsibility for the different stages of the product life cycle. In relation to this, the companies in a supply chain are responsible for both their social and environmental impact. The awareness of corporate social responsibility (CSR) has put more pressure on the decision makers within organizations to make decisions not only considering financial aspects. The pressure from stakeholders and the realization that CSR affects the financial performance of the corporation has led to that this aspect has been more integrated into the supply chain management processes.

However, Seuring & Müller (2008) argue that there are some barriers for sustainable supply chain management. The main barriers include:

- **Lack of communication within the supply chain:** If the commination level between different actors within a supply chain is low, it is hard to know how they are performing in terms of both day-to-day operations but also from a sustainability perspective. Analyzing a company's performance and getting information about their suppliers requires a lot of time and effort. Based on this, a close collaboration within the entire supply chain is required.
- **Higher sourcing costs:** The most common way to analyze the sustainability of a product is to use a Life-Cycle-Analysis. To make such an analysis, the companies need to evaluate their suppliers and develop tougher due diligence in the sourcing process.
- **Coordination and complexity:** The goal is to find a balance between improving the sustainability of the supply chain while maintaining the economic performance. It is a complex matter to implement sanctions that can be evaluated and monitored. Educating staff and ensuring it leads to the wished change is hard to evaluate. It is easy for companies to set up new policies, but it is very complicated to integrate these into the day-to-day operations to make the goals come true.

2.4 Supply Chain Performance

Chae (2009) argues that Key Performance Indicators (KPIs) is the feedback system to a supply chain and can help an organization realize the difference between plan and execution. It also helps to realize current problematic areas in the supply chain. KPIs act as a metrics system that can be used to evaluate the accuracy of planning and the performance of the execution as well as highlight gaps between these. According to Li Leng et al. (2021) a nonfunctioning supply chain flow impacts all parts of the chain in terms of service and cost. Gunasekaran et al. (2004) mean that analyzing a supply chain can be done with different aspects in mind, and it depends on what the overall goal is. There needs to be an alignment within the organization on what type of KPIs to focus on both when analyzing but also when designing a supply chain. Three examples of KPIs are: Order lead time, cost, and customer satisfaction.

2.4.1 Order lead time

Gunasekaran et al. (2004) argue that order lead time is one of the most common performance measures to use when analyzing a supply chain. The lead time is defined as the time between an order is placed until it is delivered. This is an important performance measure that affects customer satisfaction and competitiveness. However, in some cases, delivery precision is more important than order lead time. This means that it is more valuable to know when an order will be delivered rather than that the time it takes to deliver it is short. Another thing that can be analyzed is the customer order path. This means analyzing how long time each step of the delivery process takes. By looking at this, it is possible to find non-value adding activities and eliminate them to both reduce costs and lead time. By reducing the number of process steps, it is possible to improve delivery accuracy and lead time.

2.4.2 Cost

Gunasekaran et al. (2004) argues that one of the most important KPIs related to logistics is the distribution costs. There are different ways to analyze distribution costs and one option is to analyze each element individually and analyze how they impact customer service. This enables the company to identify what types of trade-offs they are willing to make. However, the authors describe that the most beneficial way to analyze costs within logistics is to look at the transportation costs since they make up for over 50% of the total logistics costs.

2.5 Supply chain visibility/traceability

Supply chain visibility and traceability are important concepts for the management of both forward and reverse supply chains. According to Dai et al. (2015), supply chain traceability systems can be used to keep information about the location of products so that all parties in the supply chain are updated on the status of the goods. Pundir et al. (2019) state that visibility can provide several benefits within supply chain management. Visibility in the transportation can lead to decreased risk of experiencing thefts and lost goods due to the ability to track the location of products. Moreover, increased customer experience can be achieved by allowing customers to track in real-time where their orders are currently located. Jayaraman et al. (2008) add that activities in the reverse supply chain are often time-sensitive, as in the case when customers are waiting to be refunded for their returns. By increasing the visibility in the flow, customers can be better updated on the status of their returns.

Furthermore, according to Jayaraman et al. (2008), supply chain visibility is a prerequisite for one of the most crucial components of efficient supply chains, namely supply chain collaboration. All actors of a supply chain can reap benefits from collaborating with other supply chain members to ensure that their processes can interact as seamlessly as possible with each other and that they are striving towards non-conflicting goals. Festus & Xiaoming (2010) state that while collaboration is of high importance in forward supply chains, it is potentially of even higher importance in reverse supply chains because there is a high uncertainty of volume, frequency and point of origin in return flows. Thus, being able to accurately track the status of orders in the reverse flow is an important factor for coordinating reverse logistics activities. Jayaraman et al. (2008) also state that the reverse supply chain contains additional steps compared to the forward chain, such as remanufacturing or disposal, which adds to the complexity of the management due to further uncertainties regarding quantity and quality of the goods.

Mahindroo et al. (2018) argue that information technology is a requirement for efficiently managing logistics activities. Having proper technology can aid firms in achieving both improved operational efficiency and flexibility, as well as being able to better plan and follow up on their activities. Available technologies include barcode scanning, RFID (radio frequency identification), Bluetooth and GPS technology (Dai et al., 2015). Moreover, Dai et al. (2015) present a number of different levels of visibility related to tracking systems. The first level is *vehicle level* which means that the vehicle in which the goods are being transported can be tracked by using GPS information. The idea is that if the vehicle can be tracked, so can the goods that are being carried. Some advantages with vehicle level tracking are that routing efficiency and resource utilization can be evaluated.

The second level of tracking is *container level* tracking. Here, a GPS device is placed on or within a container. One benefit with this level is that it is possible to follow the shipment even when switching transport modes or transport provider. It is thus not required to have the tracking provided by the transporter. The drawbacks of this level are however that providing each container with a GPS device can be costly and will require additional logistics processes for returning the device once the shipment is delivered. Additionally, the container level tracking does not give any specific information about the individual packages within a container load. The third level of tracking presented by Dai et al. (2015) is *package level* tracking. Here, individual parcels can be tracked using different IOT technologies which allows any interested member of the supply chain to follow its path. This level gives a constant visibility of where goods are located in the supply chain which means that it also enables analysis of which locations in the supply chain are subject to a high activity.

While there is no scarcity in available technologies for increasing the traceability of the reverse supply chain, there are some potential barriers for implementing them. Festus & Xiaoming (2010) mention that adopting IT solutions can be a complex task since different firms in a supply chain often have different IT systems with different data formats. This can be especially troublesome when there are many different actors within the supply chain and the information sharing needs to be integrated between all of them. Moreover, according to Dai et al. (2015), it is often difficult to quantify the costs and benefits of integrating the proper IT systems which makes it more difficult to make informed decisions when considering a potential implementation.

2.6 A network approach to reverse supply chain management

Ford et al. (2003) state that different distribution networks have high variety, both in terms of customer involvement but also in terms of complexity. In order to understand this complexity, a network approach can be used. Gadde et al. (1993) states that a network can be described as a model consisting of three different layers, these are:

- Activities
- Resources
- Actors

The three network layers are in fact tightly linked to each other but can be separated for analytical purposes. Actors are the ones that act and could be individuals, departments, firms, or company groups. The actors control resources and perform activities. Resources are used to perform activities. Resources could be both physical and human. The resources depend on each other and are heterogeneous in that their value depends on how they are used and combined with other resources. This means that each actor in a network depend on other actors.

To analyze a network, it is possible to use the three perspectives of a distribution network. The three different perspectives will be described below.

2.6.1 Activity analysis

Gadde et al. (1993) state that activities require extensive coordination since they are performed by many different actors and at different places. The activities are performed both by the firms internally but also between the different actors. One firm working with another, must also take into consideration the activities this firm has in relation to its suppliers and customers. The activities depend on one another and a change in one might require that the activities both before and after need to be adapted accordingly. Costs related to an activity depends on how dependent it is on other activities, as well as on how the single activity is performed.

One way to increase the efficiency of an activity is based on the relations between different activities. The reason for this is that the other links need to adapt to a more standardized activity. The main purpose of using standardization is to cut costs. There needs to be a balance between improving the links between the different activities while improving the efficiency of each activity. Ford et al. (2003) argue that activities that historically have been performed by one company are now often performed by multiple companies in collaboration. By doing this, companies can use each other's resources more efficiently, and each company does not need to own each resource themselves. Thus, they can create greater value together without needing to possess all resources and competences as they would when working by themselves. Specialized actors have become more common since the collaboration between company borders has increased and companies has started to focus more on activities related to their core competences. By using intermediaries specialized on certain activities, actors can develop greater knowledge as well as achieve economies of scale in their core activities.

2.6.2 Resource analysis

Ford et al. (2003) state that resources are found in many different types in a distribution network. These include resources owned by both private as well as public organizations. Resources can be both intangible and tangible. The resources can be found on all levels of a network. Companies try to find ways to use the resources as efficient as possible. To do this, companies use business relationships to get access to resources.

Gadde et al. (1993) state that how resources are organized has a great impact on the network since activities cannot be performed without resources. One way a firm can create a competitive advantage is by gaining control of a resource that their competitors lack. However, it is of great importance to utilize the resource to create value by using the activities in a beneficial way. Just acquiring a resource does not create any value by itself. A company needs to use its own resources in combination with other actors' resources to create value.

Therefore, it is crucial to analyze and understand what external resources are critical for the company's success. One option could be to develop a solution to get a certain resource in-house to reduce the dependency of other actors. This is related to the core competence of the company and understanding what they are good at. Two critical questions are what the main priority of the company is and what resources they want to take advantage of from other actors. Furthermore, when analyzing the future efforts or changes, it is important to analyze if the resources the company has in their network today will be sufficient, and what other resources they need to meet future demand.

Ford et al. (2003) mean that the efficiency of a distribution network can be improved my moving different activities from one actor to another. This means that the use of the resources within the network also changes. By viewing the distribution network as one extended company instead of several different ones, companies can realize that they could benefit from using other actors' resources and capabilities. This opens up for possibilities that they would not be able to gain by themselves.

2.6.3 Actor analysis

Ford et al. (2003) state that recent developments within distribution networks have led to greater requirements for coordination between different actors. Examples of actors could be individuals or companies such as departments, companies, or groups of companies. The relationship between actors has also gained increased importance. This is based on two factors. Firstly, activities have tended to become more specialized and shared between different actors. Secondly, suppliers have changed from having a single marketing channel towards a network of actors. The contribution from the different actors consists of their different resources, and the combination of them lead to greater efficiency for the entire network.

Gadde et al. (1993) describe that an actor analysis focuses on which actors perform which activities, which actors control which resources and how the resources relate to each other. The first step in this analysis is to understand which the main actors in the network are. The following step is to audit the actors with focus on their financials, willingness to cooperate and competence. The main purpose with this step is to find strengths and weaknesses within these areas. For instance, it could be interesting to analyze if they are facing any current or future challenges as well as what support they would need in that case. Another aspect to analyze is the location of the suppliers.

The number of actors in the network should also be analyzed since the number of collaborations make the complexity increase. Developing strong collaborations with a few actors that prioritize close development and with similar views on collaboration and future aspirations is preferable. Selecting the right suppliers and understanding them, their priorities and their situation is therefore of great importance. Seeing the different actors in the network as a source of cooperation is a great way to establish a stable network and sustainable relationships. The priorities of the company might change and the same goes for the other actors in the network. This is another factor to consider when designing or re-designing a network.

Ford et al. (2003) describe that designing the distribution as a network rather than a set of independent companies. For instance, they highlight that working with close relationships also create possible conflict. Companies that try to cooperate and use each other’s resources can also be a source of problems. Since the companies are in the network to generate profit, the distribution of the profit and the work between the different actors can become an issue of conflict.

Ford et al. (2003) present an example where one manufacturer tried to produce the highest amount of value to the highest price while the retailer wanted to secure the lowest price for these goods. They also present similar views as Gadde et al. (2003) regarding understanding the other actor’s situation. There is no guarantee that the different actors of a network have the same requirements. Conflicts can also arise when similar companies are part of the same network. The conflicts can then relate to pricing or developing new services. Hence, being part of a distribution network is about dealing with both collaboration and conflicts of interests.

2.7 Analytical framework and research questions

To properly address the aim of this thesis as well as to be able to perform an analysis on the collected information, an analytical framework has been created based on the theory presented previously in this chapter. The aim of this research is to both understand the current state of the reverse supply chain at Volvo SML, as well as to address some of the potential areas of improvement found. To do that there is need for a theoretical framework on both how to describe and evaluate the current state as well as for how the current state can be improved into a desired future state. Firstly, in order to achieve a framework for supporting the analysis, some general theory related to reverse supply chain management has been used to give an insight to some of the terminology and processes used within the reverse supply chain concept. To be able to outline the current state of the reverse supply chain, the concept of supply chain mapping will be used as a mean of presenting the different building blocks that the reverse supply chain consists of as well as how these are tied together through different types of flows. This will thus give an understanding of how the reverse supply chain is designed in terms of how the products are physically moving through the chain.

To be able to make a more in-depth analysis of the reverse supply chain and gain a higher level of detail on how it is designed, the ARA model will be used. The model will be used to gain an understanding on what different actors are operating in Volvo SML's reverse supply chain, what resources they possess, what resources are accessed through business relationships with other actors, and how resources are utilized. By using the model, an analysis can be made about how Volvo SML's network can improve their resource utilization and achieve better activity coordination. This can mean both that Volvo SML has access to those resources themselves or that they are able to make use of the resources of other actors in the chain. Furthermore, an analysis can be made on what value the different actors that Volvo SML are collaborating with are adding in the reverse supply chain, if all these actors are necessary for achieving a successful reverse distribution, or if the set of actors can be reconsidered. Perhaps most importantly of all, the model can be used to evaluate how the activities, resources and actors in the reverse supply chain are coordinated, as well as the effects of the level of coordination. Regardless of if a firm has access to all resources that are needed for achieving a reverse supply chain with high resource utilization, they have no value unless the resources can be combined with other actors resources. Hence, the flow of information including the visibility/traceability needed to allow for an efficient collaboration and coordination within the reverse supply chain will play a central part in the analysis.

To address the aim of this report, two research questions have been formulated. The first research question is formulated with the goal of gaining a thorough understanding of the way Volvo SML's reverse chain is organized today by mapping the relevant flows in their current distribution system. In addition to this, the question aims to identify areas of potential improvement in the reverse supply chains in terms of how these are organized with regards to actors, activities, and resources. The purpose of this question is to form an understanding of the effects of the company's existing ways of operating and to find the root cause of the potential areas of improvement that can be found. Research question 1 has been formed as:

RQ1: With regard to resource utilization, activity coordination and information exchange between different actors, what improvement areas can be found is Volvo SML's reverse supply chain?

By addressing the first research question, a solid foundation will be gained about the current situation along with its potential opportunities for future improvement. These findings will allow the research to be focused towards areas which can potentially bring the most significant level of impact once addressed. From an in-depth analysis of these areas using both existing literature as well as empirical findings gained from answering research questions 1, research question 2 can be answered.

RQ2: How should Volvo SML design their reverse supply chain to achieve better resource utilization, activity coordination and information flow?

3. Methodology

The methodology chapter describes the approached method that has been used to investigate the research problem.

3.1 Research approach

According to Säfsten &Gustafsson (2019) there are two different research approaches that can be used for research. These two methods are qualitative and quantitative studies, and the former has been the one used in this project. Within qualitative studies, data gathering is done by acquiring data e.g., by interviewing people and using secondary data. Based on the interviews, qualitative data is gathered, and observations and conclusions are made based on this information. Field visits were also performed to build a more thorough knowledge in addition to the interviews conducted. The approach from this type of study is that the analysis is developed through an iterative process of interactions between the researchers and the interviewees. One of the main advantages with this approach is that there is a possibility to change the purpose as the work proceeds. According to Bell et al. (2019), the qualitative research method is used to get in-depth understanding of complex problems. This method uses non-numerical data through various methods such as documental analysis, interviewing people and making observations.

For this study the main sources of data were interviews as well as secondary data. The reason why this research method was used is due to the nature of the research questions and purpose. Some quantitative data related to the topic of this project has previously been collected by Volvo SML has been used as a secondary data source where applicable.

3.2 Research method and design

The research design is based on three different phases in addition to a literature review that has been performed in parallel with the empirical research. The findings from the literature review have been used to gain a theoretical background of relevant concepts that can be used for the collection of empirical data. The three phases of research are referred to as phase 1,2 and 3 and a visualization of the research process is shown in Figure 5. The first phase consists of understanding the aim and scope of the project as well as designing research questions to fulfill the aim. In addition to this, a template for the initial interviews were made. The purpose of the initial phase was to understand the problem and understand the topics of interest before diving deeper into them in phase two.

The focus of the second phase was the in-depth interviews, as a start to analyzing the problem areas of the company with various people that were recommended as interviewees from the interviews in the first phase. The goal with this phase was to gain a more thorough understanding about the different flows in the case company's reverse supply chain and to find areas of improvement in how the company operates today. According to MacCarthy et al. (2022), supply chain mapping is a useful tool for supply chain performance management as well as for supply chain re-design and improvement. The mapping approach has therefore been a central part of the second research phase. The third phase was the analytical phase where the empirical data were analyzed, and recommendations based on the analysis has been provided. The goal of this phase was to answer the research questions and fulfill the aim.

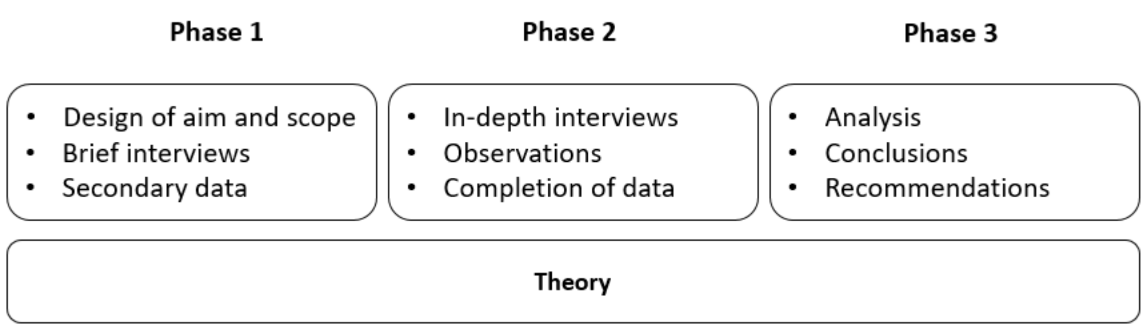

Figure 5. Research design process.

3.2.1 Data collection

For all interview-based research it is necessary to have a structural way of performing interviews and selecting the interviewees to ensure that the findings are as valid as possible. According to Parker and Scott (2019), one of the most frequently used methods to select interviewees within qualitative research is the snowball method. The snowball method is based on that a few initial interviews are made to get a brief overview of the topic of interest. The interviewees are then asked to recommend further people of interest that might be suitable for interviews more in depth. These interviewees are then interviewed on the same topic which gives the snowball effect that the range of interviewees grows in all directions.

The project started by conducting an initial interview with the project supervisor at Volvo SML to get a brief introduction to the topic and get in touch with other stakeholders within the organization that could be of interest for the research. After this initial meeting, three introductory interviews were held with people in the organization involved in work related to the thesis topic. The first interview was held with two people working in the *Transport Flow Optimization and Footprint Design* division at Volvo SML. The second interview was held with a Senior Excellence Manager, working with strategy decisions with a focus on sustainability. The third introductory interview was held with an Excellence Leader who has the responsibility for the return flow of products. These four interviews where the basis for the snowball selection, and their recommendations were used for the selection of new interviews.

The interviews were held in a semi-structured format, where some questions were formed prior to the interviews that served as a basis for the discussion. However, the interviews were not restricted to following the planned questions strictly in order to allow for some flexibility depending on how the discussion unfolded. From the initial interviews, a wider understanding was gained about the organizational structure, the distribution system, processes, as well as some problem areas in need of further investigation. The findings then served as a basis for establishing the scope and the area of focus for the thesis. Once the introductory interviews had been performed, more in-depth interviews were conducted with different stakeholders around the organization with knowledge about the different processes that are being performed in the reverse supply chain at Volvo SML. Some of the in-depth interviews were performed in combination with a field visit where there was a possibility to observe the different processes carried out at the various locations in order to gain a better understanding of how the work is performed in practice. The interviewees in the second phase of the research were chosen through the snowballing method where relevant people were recommended during the interviews conducted in the first phase. Additionally, during the second phase, the same method was used where the interviewees recommended further people with knowledge and interest in the thesis topic. The performed interviews are shown below in Table 1.

Interviewee role	Organization	Topic	Interview type	Duration
Transport developer	Volvo	General structure of the reverse supply chain	Interview	55 min
Logistics Sustainability Developer	Volvo	Overall perspective, focus sustainability	Interview	55 min
Excellence Leader	Volvo	Overall perspective	Interview	90 min
Core Technical Manager Excellence Manager	Volvo	Core hub processes	Interview	60 min
Supplier Manager	Volvo	Internal transport processes	Interview	40 min
Logistics Manager	Galliker	Transport processes	Interview + field visit	60 min
First Line Manager Order Picker	Volvo	Core hub processes	Interview	60 min
VP Warranty Material	Volvo	Warranty process	Interview + field visit	100 min
Business Controller	Volvo	Financial perspective	Interview	60 min
Excellence Lead Finance	Volvo	Financial perspective	Interview	55 min
Logistics Manager	PostNord	Transporter perspective	Interview + field visit	100 min
Dealer Representative	Volvo dealer	Dealer return processes	Interview + field visit	120 min
Dealer Representative	Private dealer	Dealer return processes	Interview + field visit	120 min

Table 1. Overview of performed interviews

3.2.2 Trustworthiness

According to Connely (2016), trustworthiness plays a vital role in ensuring the integrity and usefulness of the conducted research and its findings. The term trustworthiness refers to the accuracy to of methods, interpretations, and data. Trustworthiness consists of several areas, three of which are: dependability, creditability, and confirmability.

Dependability means to secure the consistency of data over time throughout the study. Dependability is performed on the nature of the study, i.e., how the research has been designed to ensure that the same results could be achieved if the study was performed by someone else. To enhance dependability, different methods can be used to ensure the trustworthiness of the study. One way is to use process logs, i.e., notes of the activities performed during the research. It also includes reasoning about why certain decisions are made, such as the choice of data sources or why a certain research method was selected. Ensuring dependability could also mean to have peer-debriefings. All phases of the research process should have consistent and available reports on why they were made and should be critically reviewed. According to Patton (1999), creditability refers to the trustworthiness of the study and its findings. This refers to whether the results of the study are valid or not. Therefore, the creditability depends on both the researchers as well as the research design. Here, it is crucial that the researchers have interpreted the empirical data in the right way, and that the conclusions are correct. It also includes whether the research design was made to allow for unbiased findings. One way to improve credibility is to transcribe interviews. The results should be questioned and reviewed multiple times and include negative results in the study as well. Connely (2016) state that confirmability refers to the degree the research findings can be repeated. Methods to ensure confirmability are audits and methodological memos. This means that the researchers keep notes about their progress and the decisions made. These notes can be reviewed, e.g., by a colleague, or discussed through peer-debriefings.

For this study, trustworthiness was secured in the research design through several actions. Firstly, the research method was designed by the researchers, but was reviewed by the supervisors from both Volvo SML and Chalmers University of Technology. This means that people that were not active in the research process and performing the interviews had the ability to approve the research process. Their thoughts on the research process were taken into consideration before making a final decision. Secondly, interviews were held with different divisions within the focal company to ensure that multiple points of view were given on the addressed problems. By gathering data from different people, in different divisions, and in different positions, increased dependability could be achieved. Thirdly, all progress within the research was noted and checked by both researchers. All interviews were transcribed and reviewed multiple times. After this, the collected data was cross-checked both with the supervisors at Volvo SML as well as the interviewed people. Moreover, to ensure credibility, the theory used in the study was selected to include various aspects that could both strengthen and weaken the results of the interviews. To perform the analysis, a proven theoretical research framework was used to increase the creditability. By using this framework, it limited the researchers from making biased conclusions to strengthen the results of the thesis.

4. Empirical findings

In this chapter, the empirical findings from the research are presented. Firstly, the different return types in Volvo SML's reverse supply chain are presented. Following this, the structure of the reverse supply chain is described followed by an explanation of how the products flow through the system depending on return type. Lastly, a more in-depth presentation of the processes that are performed at the various locations in the reverse supply chain is given.

4.1 Return types

There are four different types of product returns in Volvo SML's reverse supply chain. These return types are referred to as discrepancies, warranties, cores, and buybacks. Discrepancies are non-used products which are faulty for some reason. Reasons could be e.g., aesthetic, or functional quality issues, that the wrong parts have been received by the dealer, or that the dealer has ordered the wrong products or quantities. Warranties are products that after use have been found to not meet the expected quality and thus should be returned for a potential refund. Warranties and discrepancies are treated similarly when it comes to the return distribution from the dealer's perspective since they are returned on a continuous basis when the need for a return arises.The third type of returns, cores, are products which are eligible for remanufacturing. These products include critical components such as gearboxes and engines which are worth remanufacturing to capture the remaining value of them instead of scrapping them. The core products are, much like warranties and discrepancies, returned on a continuous basis, but given that the return process for these products include a remanufacturing step, they are treated somewhat differently in the reverse supply chain. When a dealer receives a core from a customer, the product is replaced with a so-called exchange product. Exchange products mean that the customer will, if possible, receive a similar product which has already been remanufactured. These exchange products are sold at a lower price than a new product of the same type would have been sold for. However, since not all core products are able to be remanufactured in practice, the customer will sometimes receive a newly manufactured product, although at the same price as an exchange product.

Buyback is the fourth type of returns and differs from the other three return types due to the approach Volvo SML has to supplying parts to their dealers. Volvo SML uses a push-oriented method of supplying parts to their dealers called DIM (dealer inventory management). The way this method works is that Volvo SML automatically sends out parts to their dealers based on their projected demand, although dealers still can order parts manually. These products might not always be used by the dealer, and if they sit in stock for a certain period, Volvo SMLwill take them back to their distribution center and refund the customers. Buybacks then refers to the products that have been pushed out to the customer and are taken back if not sold. The policy for buybacks is that they are taken back if they are not sold within a certain amount of time. The number of buybacks offered during a year depends on the sale volumes at the dealer. The dealers have a range for the stock values that are considered acceptable and when the level exceeds this range, buybacks are initiated. The buybacks differ from the other return types in the way that these are periodically returned during certain time periods as opposed to being returned continuously.

4.2 Supply chain structure

The reverse supply chain at Volvo SML consists of several different actors and facilities. These are depicted in Figure 7. Furthest downstream are the end-users which are the customers using Volvo SML's end products, i.e., the vehicles. In the case of the spare parts market, the customers are facing dealers which are the ones performing maintenance and repairs on the customers' vehicles and therefore are keeping stocks of spare parts at their facilities. Moving upstream the reverse supply chain, Volvo SML has different kinds of distribution centers which are supplying parts to the dealers. Central distribution centers (CDCs) are the largest distribution centers in the network which have the largest number of products available in stock.

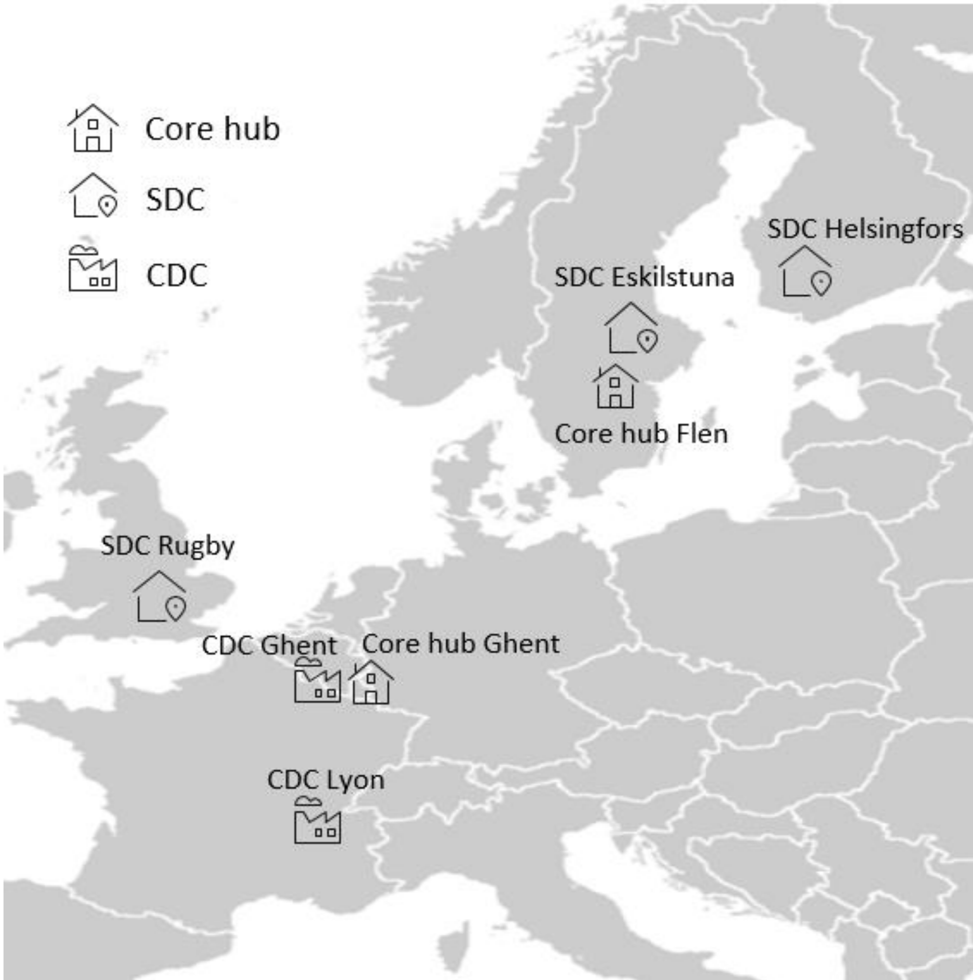

Figure 7. Overview of distribution centers and core hubs included in the EMEA region.

Some dealers that are located far away from CDCs are also facing so-called SDCs which are supporting distribution centers. The CDCs are responsible for supplying stock orders to the dealers, i.e., non-emergency orders. The role of the SDCs is instead to supply urgent parts to the dealers that are not able to be delivered from the CDCs on time. SDCs thus have a smaller product assortment than the CDCs and the majority of deliveries should come from the CDC if possible.

In Europe, there are two CDCs located in Ghent in Belgium as well as in Lyon in France. All products in the outbound flow of products go through these CDCs regardless of whether they are going directly to a dealer or from an SDC. For dealers that are located close to the CDCs, these also act as SDCs for those particular dealers. The SDCs in the northern region are located in

Rugby in England, Helsinki in Finland and Eskilstuna in Sweden. The transports within Volvo SML's return flow are performed by 3PL companies who have their own facilities such as terminals and warehouses. These facilities are therefore also a part of the reverse supply chain and although not directly controlled by Volvo SML, the processes at these facilities still impacts how the reverse supply chain functions. Similarly goes for the remanufacturing and recycling operations which are also handled by external companies while still having a key role in the reverse supply chain.

4.3 The return flow

Figure 8 illustrates the physical flows in Volvo SML's reverse supply chain for the respective return types. The illustration is based on the case of returns from Swedish dealers and the descriptions of the flows will thus be centered on the nodes in the reverse supply chain that are part of those flows. In the Swedish case, Carrier 1 *(C)* represents PostNord, Carrier 2 *(D)* represents Galliker, Carrier 3 *(F)* represents Lundbyåkeriet, and the SDC *(E)* refers to SDC Eskilstuna. The flows for the remainder of the countries included in the EMEA north region have similar setups with some slight differences in what carriers are used for transports as well as which SDC the dealers are facing. A description will be given here about the journey a product takes through the reverse supply chain, and later, a more in-depth explanation will be given regarding the processes that occur at the respective steps.

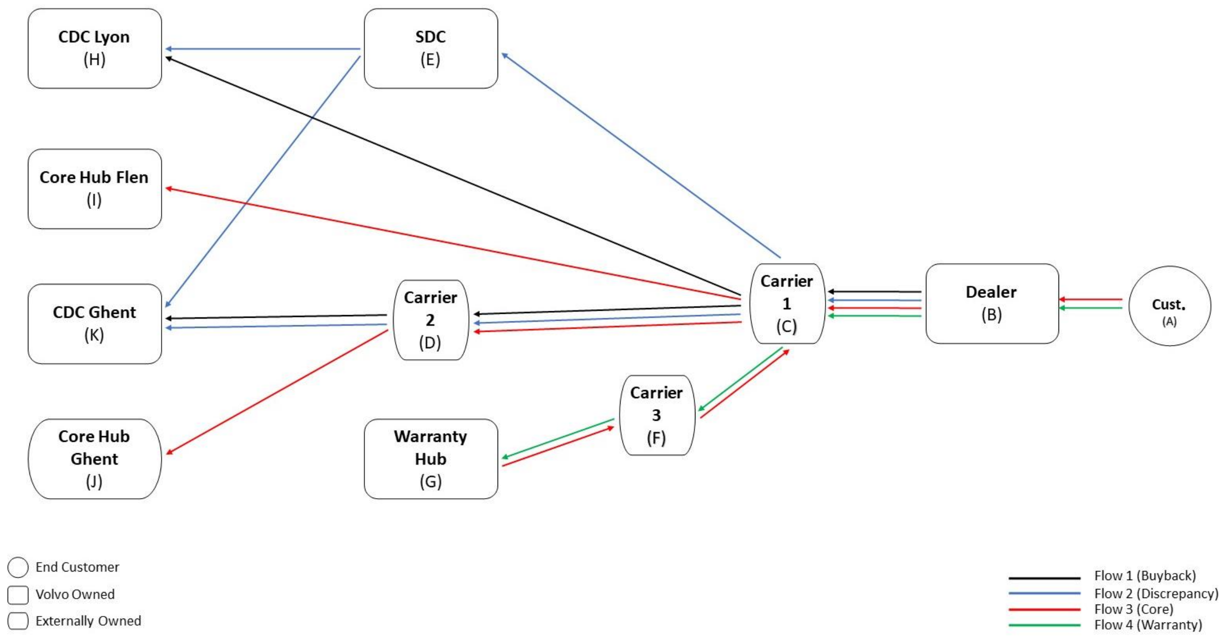

Figure 8. Illustration of the reverse flow

When mapping the return process of Volvo SML's reverse supply chains, the flow starts at the end customer *(A)*, i.e., the point located furthest downstream when looking from an outbound distribution perspective. In order to avoid misconceptions, the customer end will henceforth be referred to as downstream and the manufacturing end will be referred to as upstream as in the case of outbound distribution. The flows corresponding to each specific return type will be referred to as Flow 1 (Buyback), Flow 2 (Discrepancy), Flow 3 (Core) and Flow 4 (Warranty).

4.3.1 Flow 1: Buyback

For Flow 1, the parts have not yet reached the end-customer *(A)* before being returned and thus the return process starts at the dealer *(B)*. The dealer books a transport from a carrier which in the Swedish case is PostNord *(C)*. For products that are going to Belgium, PostNord only takes care of the first leg of the transport out from the dealers to a terminal where the products are consolidated with returns from several dealers within the covered area. The transport between Sweden and Belgium is instead performed by the company Galliker *(D)*.

Galliker *(D)* picks the product up at the PostNord *(C)* terminal from where they transport the return products back to their own terminal in Arendal. At their Arendal terminal, the products are sorted based on their return type. The products are then transported to the CDC *(K)* in Ghent. For

Renault Trucks, the products are transported using PostNord *(C)* the entire way between Sweden and CDC Lyon *(H)*. This flow thus differs from the products going to Belgium by the fact that there is only one carrier involved from the pickup at the dealer until the products reach their end destination. See Figure 9 for an illustration of Flow 1.

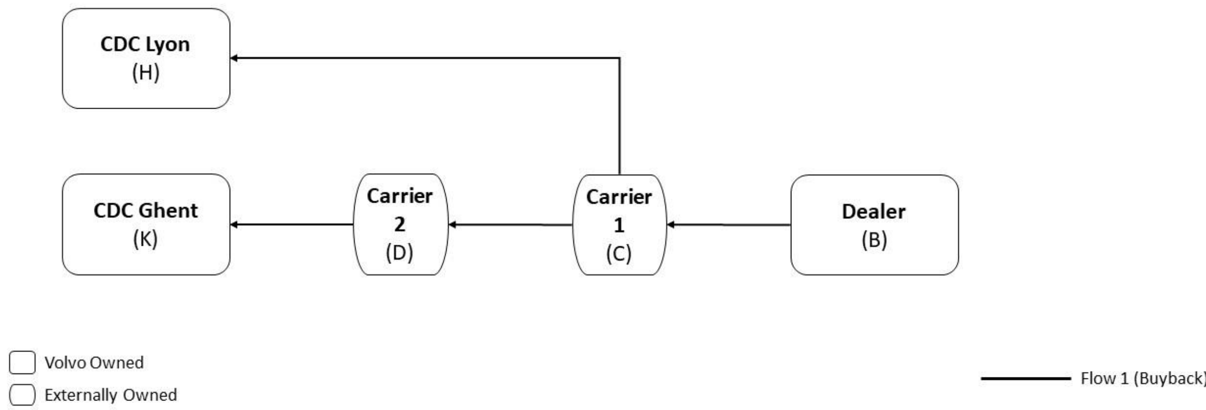

Figure 9. Buyback return flow.

4.3.2 Flow 2: Discrepancy

Discrepancies are, similarly to buybacks, products that have not yet reached the end-customer *(A)* before being returned and thus the return process starts at the dealer *(B)*. The discrepancies follow to a high degree the same path as the buybacks with one important exception. All return products must take the same path in the return flow as they have in the outbound flow due to VAT regulations. Some of the discrepancies are products that have originally been supplied from an SDC *(E)*, meaning that they need to go through the same SDC in the return flow as well due to VAT regulations. The VAT regulations govern the financial flow and therefore, the products need to be transported to the SDC initially to follow financial regulations. At the SDC, there are no inspection processes in place which means that return products cannot be put back into stock at the SDC. Thus, the return products that go through the SDC will in the end need to be transported back to CDC Ghent *(K)*. Discrepancy returns that do not go through an SDC are consolidated with buybacks the entire way from dealer to CDC. See Figure 10 for an illustration of Flow 2.

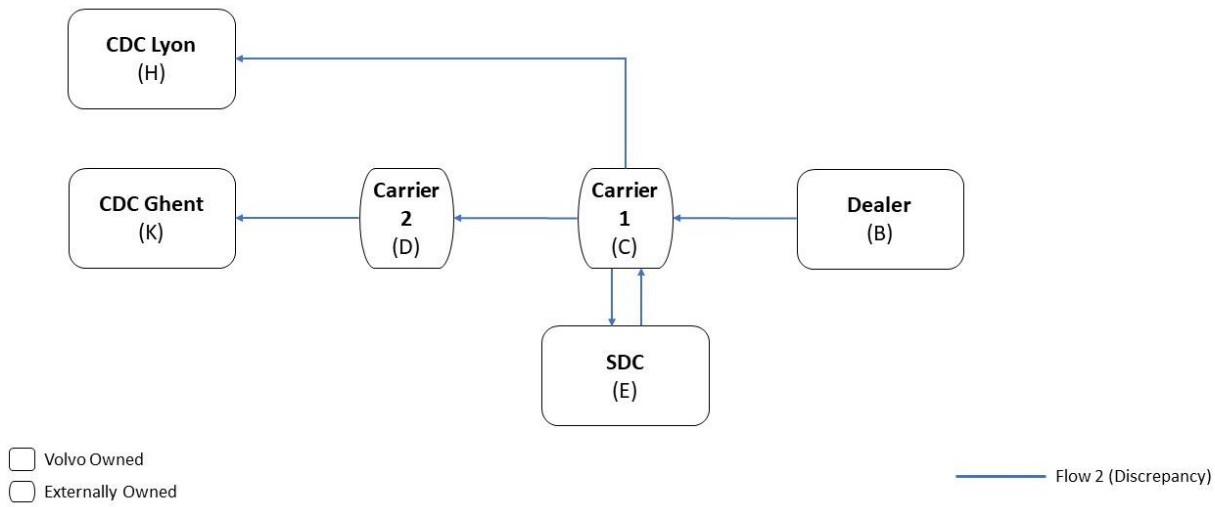

Figure 10. Discrepancy return flow.

4.3.3 Flow 3: Core

Flow 3 starts with that the end-customer *(A)* brings a faulty part to the dealer *(B)* which will be taken back for remanufacturing. However, even though the return flow starts at the end-customer, the end-customer does not have any further responsibility related to the return flow apart from getting their vehicle to the dealer.

The beginning of the journey is similar to Flow 1 and 2, with PostNord *(C)* handling the first part of the transport and picking the return products up at the dealer *(B)*. However, after this, the flow can take two different paths. The majority of the core products are sent to core hub Ghent *(K)* which is operated by the company Tropack. However, some products (e.g., engines and gearboxes) are sent to core hub Flen *(I)* in Sweden. Flen was previously a core hub handling all types of core products, and the flow was therefore similar to the current flow to Tropack. However, a decision was made to centralize the core operations to the CDC in Ghent. Despite this, Flen still receives core products when they can perform remanufacturing themselves, as opposed to Tropack who receives all types of cores and then sends them out to their respective remanufacturer. The products that are going to core hub Flen are transported the entire way by PostNord *(C)*, while the products that are going to core hub Ghent are transported by both PostNord and Galliker *(D)* in a similar manner as Flow 1 and 2. Although Flow 3 has Ghent as the final destination for the products just as Flow 1 and 2, the core products have to be transported on separate trailers than buybacks and discrepancies given that they are going to different warehouses. Flow 3 is thus not consolidated with the other flows from Galliker *(D)* and onwards. See Figure 11 for an illustration of Flow 3.

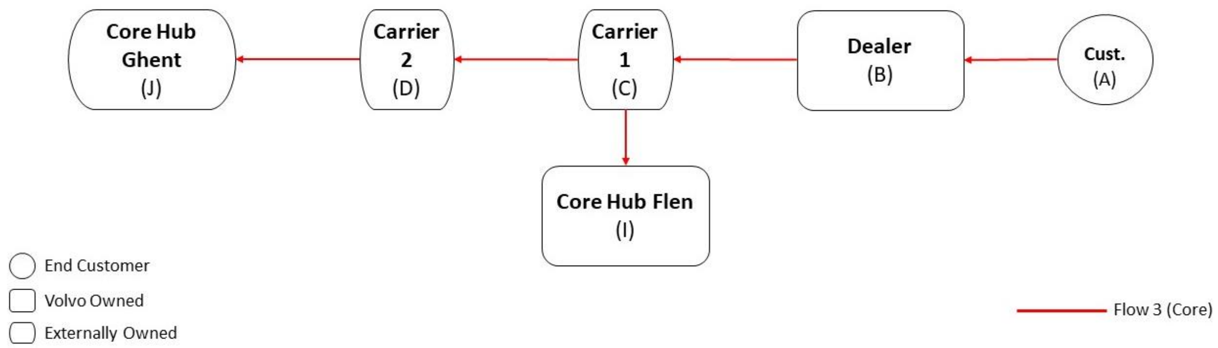

Figure 11. Core return flow.

4.3.4 Flow 4: Warranty

For Flow 4, the flow starts with that the end-customer *(A)* brings a faulty part to the dealer *(B)*. As for the other flows, PostNord *(C)* takes care of the first leg of the transport from the dealers. The products are then transported to a logistics hub in Sörred, Gothenburg operated by the logistics company Kuehne+Nagel before the carrier Lundbyåkeriet *(F)* takes over the shipment and delivers the products to a warranty hub in Lundby, Gothenburg. The transport services performed by Lundbyåkeriet are part of the contract signed with the logistics hub and performs daily transports to the Warranty Hub *(G)*. Once the products have been delivered and inspected at the warranty hub, they are transported to one of several different destinations depending on the case. Some warranty products go directly to recycling if no further investigation will be made while others are sent back to the supplier for an analysis. The last option is for products that apart from being warranty claims are also core products. These are transported to either core hub Flen *(I)* or core hub Ghent *(J)* from where they can be sent to a remanufacturing facility. See Figure 12 for an illustration of Flow 4. Note that core products are regarded as warranty products on their way to the warranty hub. After the processes have been finalized at the warranty hub, the core products are treated as non-warranty core products on their way to the core hubs.

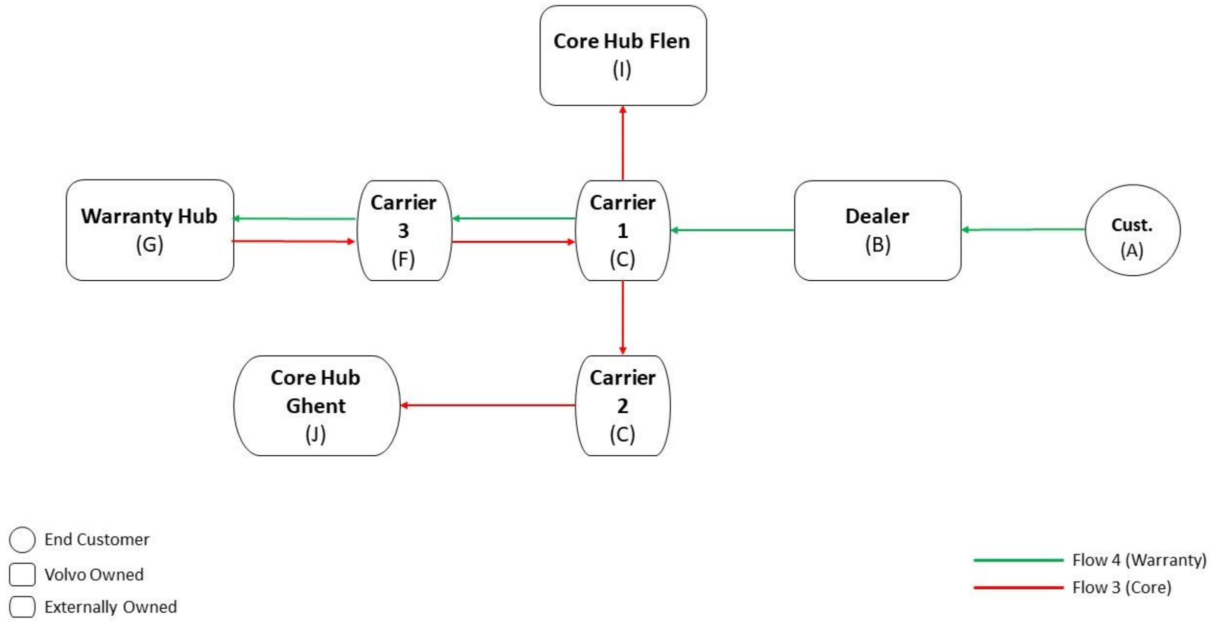

Figure 12. Warranty return flow.

4.4 Reverse supply chain processes

4.4.1 Dealer processes

The return process starts with that the dealer registers return products in one of their systems depending on the return type. The dealer then needs to have their return approved by Volvo SML in which case they will receive a so-called return permission. A return-permission includes an order number and specifies the parts that are included in a single return order. Once the return permission has been received, the dealer registers in the system which products that should sent back. When all return products in an order are registered, the dealer packs the products and prepare them for transportation.

Once a return has been approved and packed, it is the dealer's responsibility to book a transport from the carrier responsible for the transports in that region, e.g., PostNord in Sweden. In general, the carrier picks up return products when they are doing outbound deliveries. It does however happen that return products cannot be picked up in connection with the outbound deliveries for example due to lack of capacity in the vehicles. In those cases, another truck needs to be sent to pick these products up.

In order to make sure that the products are returned to the right destination, the dealer is responsible for printing out shipping labels which need to contain some specific information such as delivery address and weight. These shipping labels are printed through the carrier's booking system and are used only by the carrier during transport and handling of the products. Apart from this, the dealer also needs print out an additional label to specify the product brand, return permission number, as well as the return type which is indicated by a numbering system where e.g., core products are specified by the number 10. The information on this label is not used by the initial carrier (PostNord) during transport but is instead used to support the processes in later steps of the reverse supply chain.

The dealers' return processes are highly manual. The different steps include typing the article number of return products by hand into the computer systems, as well as keeping hand-written notes that contain information about the return products in folders while waiting for a return permission. The dealers must also keep track of which products have been supplied from which distribution center in order to send them back the correct way when making the returns. The execution of the processes differ slightly among the observed dealers without much standardization or guidelines regarding how the processes should be carried out.

Moreover, there are multiple different IT systems used to register return orders depending on the return type. Core and warranty returns both have different IT systems while buybacks and discrepancies share another system. Apart from the systems used for registering and requesting returns, the dealers also have internal warehousing systems in which they need to adjust stock balances after registering a return. The last step in the dealer's return process is to match the invoices in their invoice system once they get refunded for their returned products. This is done in yet another IT system, which means that a dealer needs to use five different systems when handling the return processes. Dealers do not currently receive any notifications or updates on when their refunding will be made, resulting in that they need to regularly go into the invoicing system to check which orders have been refunded. There is no promised lead time for the dealers between registration of returns and refunding, and this lead time can vary a lot between orders.

4.4.2 Transport processes

4.4.2.1 PostNord

PostNord is responsible for all outgoing transports from the dealers in Sweden. However, whether PostNord is responsible for the entire transport from dealer to the destination of the products depends on the return type. As described in section 4.3, the returns for which PostNord are responsible for the entire transport are core returns to Flen, discrepancy returns to SDC Eskilstuna, as well as buyback and discrepancy returns to Lyon. For these returns, Postnord will pick the products up at the dealers from where they will transport them to one of their own terminals depending on the location of the dealer. At these terminals, the products are consolidated with other products that are going to the same regions before they are transported to their destination.

For the remainder of the returns, PostNord is only partly responsible for the transport from dealer to destination. In the case of warranty returns, PostNord transports the products from dealer to a terminal in Sörred Gothenburg from where the products are transported with Lunbyåkeriet together with other products going to the Lundby area in which the warranty hub is located. The last types of returns that PostNord handles are cores, discrepancies and buybacks going to Ghent. These returns are all transported from the dealers to a PostNord terminal located in Bäckebol outside of Gothenburg from where they are handed over to the transporter Galliker which is responsible for the transport from Sweden to Ghent. Once the return products reach the terminal in Bäckebol, they are grouped together and placed in a specific area of the terminal from where they will eventually be loaded onto an outbound trailer. The loading occurs when Galliker, who is also responsible for the outbound transportation from Ghent to Sweden, arrives at the terminal with the outbound products. Since they have the responsibility for the transport on the remaining route of the return flow from Sweden to Ghent, they pick the products up and deliver them back to their own terminal.

In order to keep track of the products in PostNord's flow, PostNord use barcodes on the pallets that contain information about where the products are going. These barcodes have been printed by the dealers prior to sending out the products. The barcodes can be scanned by PostNord to send information to their internal systems when a package has reached a new destination or gone through a certain process. This means that the status and location of a pallet can be tracked as long as it is within the part of the distribution system where PostNord is responsible. This information is also available to the dealer. Apart from PostNord's shipping labels, the pallets also have Volvo return labels attached to them, carrying information about return type, return permission number and final delivery destination. These labels let PostNord know that the products are in fact return products and thus should be handed over to Galliker for further transport. PostNord's own shipping labels have their Bäckebol terminal as the end destination due to that Bäckebol is the last part of the flow that they are responsible for. At the same time, Volvo's return labels only specify the destination in Ghent meaning that there is no information explicitly stating that the return products should go through Galliker's terminal. There is thus an information gap which leads to that the terminal workers at PostNord need to know that all Volvo SML return products should be handed over to Galliker. This means that the workers need to be aware of the where the products should be sent.

4.4.2.2 Galliker

Galliker makes daily deliveries to the PostNord terminal in Bäckebol. Galliker then transport the return products back to their own terminal in Arendal. Galliker does not possess any information about the return products they handle aside from the information available from the Volvo return labels on the pallets. At the Arendal terminal, the products are sorted based on return type, something that needs to be marked on the packaging by the dealers before sending them out for return transportation. After Galliker has picked up products from the PostNord terminal, they store the products at their own terminal until enough volume has been accumulated to fill up a trailer. Since products will only be consolidated if they share the same delivery address, products often remain at the terminal for around a week before enough volume has been collected for each return type to avoid running half empty trailers.

While the outbound products are transported between Belgium and Sweden with truck in order to secure a short lead time, return products are shipped on trailers which are reloaded to sea transport using RORO ships from Sweden to Ghent. The return flow is thus significantly slower than the outbound flow since the boat alone takes 1.5 days for transport with around two additional days required for reloading. When the trailers finally reach their end destination in Ghent, the trailers containing cores are unloaded at Tropack and the ones containing discrepancies and buybacks are unloaded at the CDC.

The information exchange between Galliker and the receiving facilities in Ghent is limited. As an example, the CDC do not have any information in advance regarding what products they will receive in terms of return products until they arrive to the facility. However, they do have some information from the carriers about when a truck will arrive and how many packages the shipment will contain. Additionally, they can see in their systems which return orders have been released but they do not have any status on when these specific orders will arrive at the CDC.

One reason for the limited exchange of information between Galliker and the receiving facilities is that Galliker do not perform any scanning of the packages in the return flow. After they pick up the return products at PostNord's terminal and transport them to their own terminal, they do not make any confirmations that they have taken over the responsibility of the products. Instead, they count the number of pallets and manually check the weight stated on the return labels to register them in their own computers. Furthermore, the only scannable labels on the pallets are the PostNord labels which cannot be scanned by Galliker to make the process more efficient. There is no information exchange between PostNord and Galliker either regarding the quantities or weight of the products that is exchanged between them. As previously mentioned, it is possible to follow the status of a return transport as long as it is currently within PostNord's area of responsibility. Once Galliker takes over the transport, there is no such possibility anymore which leaves an information gap between the point where the products leave the PostNord terminal until they arrive at their end destination.

4.4.3 CDC processes

The Volvo CDC in Ghent (*K*) is responsible for receiving and controlling the parts before putting them back into stock and are thus not responsible for things such as managing transports and finances. The warehousing staff start handling the returns once they are unloaded at the warehouse. The unloading is done at the inbound area of the warehouse where trailers arrive every day. The CDC has trailers arriving from Galliker, which from some regions can include cores which are then shipped to Tropack once the other return types have been unloaded. The third transporter that delivers return products to the CDC is Ewals. They are responsible for the transports from the SDC in the UK to the CDC Ghent. The UK shipments previously had a problem where the transporter delivered the products whenever they wanted but nowadays, they have better communication allowing them to agree on which days the products can arrive. This is due to capacity constraints at the receiving area since the operators working there only work during day hours. If trailers arrive during later hours, the warehouse workers do not have the ability to unload the trailers which can cause increased lead times in the warehousing operations.

If they know beforehand when trailers will arrive, they are able to better plan their work and make sure that the trailers are able to be unloaded.

Tropack uses drop-off trailers while Galliker and Ewals have live unloading meaning that the unloading takes place while the truck is waiting at the dock. For these deliveries it is therefore important that they arrive at the agreed time because otherwise they cannot guarantee that they can be unloaded. The Galliker trailers are a bit unpredictable in terms of when they arrive and how many pallets they contain. Sometimes nothing will be delivered in a week and other times they will deliver 4-5 times during a week. One of the challenges at Volvo SML is that they do not really have a steady flow of return products and have lots of peaks in the delivered volumes. Sometimes they will get several full trailers from Galliker but sometimes it might just be a few boxes in a trailer. This makes it hard for Volvo SML to do their man-hour planning.

After the products arrive and are unloaded, the sorting process begins where Volvo SML staff need to identify what has been received. Here they need to sort which of these items should be handled at the CDC and which items need to be sent to Tropack. Sometimes they do not know what is inside the packages, which means that they need to open the packages to check the content in order to sort it correctly. Depending on which geographical market the products arrive from, it may take a lot of work if they are not pre-sorted or labeled correctly. Some markets, for example Germany, announce the number of packages and product information beforehand. In other markets they simply put everything in a box without any structure.

As previously mentioned, Volvo SML requires their dealers to put a label on the case that specifies the return type, and thus where it should be sent. This is important to keep track of not only because the label dictates where the returns should be transported but also because different return types have different priorities. Discrepancies for example have a higher priority than buybacks and should therefore be handled first. This is both due to that the discrepancies are often in smaller quantities than the buybacks (sometimes only one or a few items while buybacks are always large quantities), and because these types of returns are often due to an error caused by Volvo SML. Therefore, they want to give the customer the highest possible level of service for these items.

When the products have been sorted according to return type, they are moved from the unloading platform and afterwards brought into the warehouse to different sections based on their return type. The discrepancies are handled first given the higher priority and the products are quality checked to see if they can be put back into stock. The inspection can differ depending on the type of return. For example, if a return has been made because there has been an error in the picking process and the customer received the wrong product, the products can be put back into stock without further inspection. If there is a quality issue, other actions are taken depending on the type of issue.

If the products have serious quality issues, they usually get scrapped. In other cases, products might have been mixed up so that different customers receive each other's products and then they will try to send them back to the right customers. If possible, they try to rescue as much of the products as possible to avoid scrapping. The warehousing staff are the ones making the decision whether a product should be scrapped or not. However, they are located close to the quality department so if they have more technical questions, they can consult with them. The hard part is usually not to determine if a product needs to be scrapped or not but to determine if the cost should be put on Volvo SML or the customer.

The current lead time for the return of products is 2 weeks, which is defined as the time from when the products arrive and the labels for the return permission are printed, until they are put back into stock or scrapped. The return volumes are in general subject to a lot of variation. There seems however to be a pattern in the variation of volume over time where some specific periods over the year always experience peaks in volume These peaks can have a large effect on the lead time of the return operations because there is no good way of working proactively to address this. There is no leveling of the volumes right now because the different markets have fixed times during the year when they do the buybacks. One way to improve this can be to investigate if there is a possibility of spreading out these periods more over the year to avoid the large peaks. When dealers receive their return permission, they are free to make the returns any time they want which usually ends up being when they have slower work periods or when they have extra manpower. Some dealers choose to send their returns immediately after they receive the permission while others wait until they have several return permissions and send them all out at once. The rules now are, however, that when a dealer receives a return permission, they need to send the return products within one month and if not, they will lose the permission. Some efforts have been made to try to level the volumes by using a specific calendar setup, but this only concerns the buybacks from individual dealers which are quite small in volume compared to the returns from all dealers.

4.4.4 Core hub processes

A core hub is defined by Volvo SML as an entity that performs unloading, inspection and sending of core products. When a dealer makes a purchase on a core product, they are also responsible for making a return to a core hub after use, so it can be remanufactured. To incentivize the return, the dealer needs to pay a deposit fee when buying the exchange product. This deposit is then repaid to the dealer once the used product has been received at the core hub. The deposit fee repayment is one of the main activities that the core hubs are responsible for and the processes performed at the core hubs are designed to accommodate this. In addition to this, they also perform the remanufacturing activities related to the core products. The core hubs have no responsibility of the supply of already remanufactured products to dealers, but only for the activities performed related to the return flow. From there on, the remanufactured products are supplied in the outbound flow.

When transports arrive at the core hub, Volvo SML staff place the pallets in an inbound are where the products are being inspected. The pallets they receive usually have mixed contents meaning that a pallet can contain multiple different products. The products are inspected to ensure that the correct products have been received. They are then evaluated in terms of if they are eligible for remanufacturing or not, which depends on the condition of the products as well as if they are part of the exchange program. Some products that are collected by the core hubs are products that do not yet have a remanufacturing process set up. These products are stored at the core hub due to that they have an intention of establishing remanufacturing processes for them in the future.

Once the products have been inspected and evaluated, the products which are not eligible for remanufacturing are sent to disposal. The products that are going to be remanufactured are sorted by article number and placed in pallets so that products that are going to the same remanufacturer are stored together in a separate storage area. The Core Management System (CMS) is used as support to determine where the different products should be stored in the core hub. Each storage area is dedicated to certain products that are going to the same remanufacturer and if a product is placed in the wrong area, the system will generate a warning that the article number of the product does not match the remanufacturer connected to the storage area. Once the products have been sorted and consolidated, they are prepared to be transported to their corresponding remanufacturer. From that point on, the responsibility of the core hub ends, and the remanufacturer is responsible for sending the products back to the outbound flow.

When it comes to the information flow between the core hubs and transporters, it is an area that could potentially be improved. There is currently no visibility of what products the vehicles contain. The Volvo SML staff core hubs might know that there is a shipment going from a dealer to one of the hubs, but they do not have any information about which core return order the shipment is connected to and thus no information about what it contains. The dealer wants to receive better status updates on their core returns since they are waiting to be refunded for their deposit fees. Since they do not have sufficient visibility of the returns, they are also experiencing problems related to lost or missing products. As a result of not being able to see where in the transport network the products are currently located, there is an information gap between the point when dealers place their return orders until the pallets are unpacked at the core hubs. The transporters have information about the status of their own transports, the issue is however that there is no link between the transporter's internal identification numbers and the identification number in Volvo SML's system.

Another problem area experienced by the core hubs is that there is a lot of variation in terms of when inbound trucks arrive at the core hubs with the return products. There are currently no restrictions regarding when inbound transports are allowed to arrive at the core hubs which leads to uneven workloads and difficulties in planning. The Core Technical Manager states "*There is chaos regarding which time of the day a truck arrive at the core hub, or what day they arrive. Some days a lot of trucks arrive at the same time, and other days there are no trucks arriving at all. It is not evenly spread out and when trucks arrive tightly, it results in that they must wait to unload*".

4.4.5 Warranty Processes

The warranty flow differs from the remaining return flows from the fact that not all warranty products are being physically returned. The products which are not physically returned are instead sent for recycling directly from the dealers. If a warranty product should be returned to the warranty hub or not is determined by several different factors. The warranty department has a set of markets in Europe from which they can retrieve products that have been warranty claimed. Products that are claimed on other markets than those are only physically retrieved in certain cases where there is a special request from the warranty department.

When a dealer on one of the reference markets registers a claim in their warranty system, there are two different scenarios that can occur. The first option is that there is no request from the warranty department to retrieve the product. In that case, the dealer will dispose the product. Currently, around 4% of warranty products are physically returned, meaning that the remaining 96% are being disposed directly by the dealers. The second case is that the warranty department wishes to retrieve the product. The way the warranty department asks a dealer to make a physical return of a claimed product is that they add a signal into the warranty system for all products that, in the case of a claim, should be returned. The warranty department also has the ability to request a return for a claimed product within 30 days from the point when the claim was made. The dealer thus has to save all warranty products in stock for at least 30 days before they are allowed to dispose them.

The reason for physically returning warranty products is to make analyses on quality issues which is done either by Volvo SML themselves, or by the suppliers. This means that the return flow of the warranty products does not always stop at the warranty hub, since the products might sent to a supplier. Additionally, warranty products can sometimes also be core products. In that case, the products are sent back for remanufacturing after they have been analyzed and thus, the flow of core products continues beyond the warranty hub.

When a transport reaches the warranty hub, the products are unloaded in an inbound area where they remain until they can start being processed. At the warranty hub, the main process is referred to as a theoretical inspection of the warranty products. This is to ensure that the correct products arrive, as well as that the claim is correct. The warranty department can reject claims if they find that products do not live up to the warranty policies. Once the theoretical inspection has been performed at the warranty hub, the products are sorted and stored based on product type. The warranty department adds information into the warranty system specifying where in the hub the products that have gone through inspection are stored. Thus, if the person who has ordered the warranty product comes to the hub themselves, they have the information stored about where the product is located. Otherwise, the products will instead be transported to the person that has placed the warranty order.

There are a few requirements on lead times when it comes to warranty products. Firstly, when a dealer places a claim on a product, the dealer is required to send the product within 10 days. At the same time, the warranty department requires that the products arrive at the warranty hub within 21 days from the point when the claim was made. The reason behind these lead time requirements is that the claims are automatically revoked if the claim has not been processed at the warranty hub within 60 days from the point when it was first registered by the dealer. These 60 days include the time when the products remain at the warranty hub before they have been unpacked. If a claim is revoked, and the products arrive later, extra work needs to be put on correcting the payments afterwards. The lead time requirements are the same for all markets within Europe. However, the 21-day requirement from claim registration to arrival at the warranty hub is in general mostly fulfilled by Swedish dealers.

Through the warranty system, the staff at the warranty hub can see which products have been claimed which lets them know the number of products that should be arriving at the hub in the upcoming time. Furthermore, the dealer is required to register a dispatch date in the warranty system when a claim is sent which gives an indication of when the products should arrive. However, the dispatch date is not necessarily the exact time the products have been picked up by the transporter but rather when the products have been prepared for transport and when the transport has been booked. While this information provides some predictability to the number of incoming products, there is no data available between the point in time where the claims are registered until they arrive at the warranty hub. There is no reporting on when the products have reached a certain stage in the reverse supply chain and no way of tracking the products. This also makes it impossible to do any kind of follow-up on the lead times of certain parts of the chain and to trace what has happened to the products in case they get lost.

When it comes to improvement areas in the warranty flow, the speed of transports is not regarded as the most important factor. Precision is seen as a more important performance measure as the lead time can currently vary a lot in some situations. Sometimes the products will arrive at the warranty hub within two weeks from the time when the claims are registered, while other times it might take two months. These lead time deviations make the work less predictable as well as leads to extra work when products arrive for which the claim has already been revoked.

5. ANALYSIS

In this section, an analysis is performed based on the ARA-Model and applied to the reverse supply chain of Volvo SML. The activities, resources and actors included in the reverse supply chain will be analyzed respectively, as well as the dependencies between them.

5.1 Activity analysis

The main activities in Volvo SML's reverse supply chain are presented in Figure 13 below.

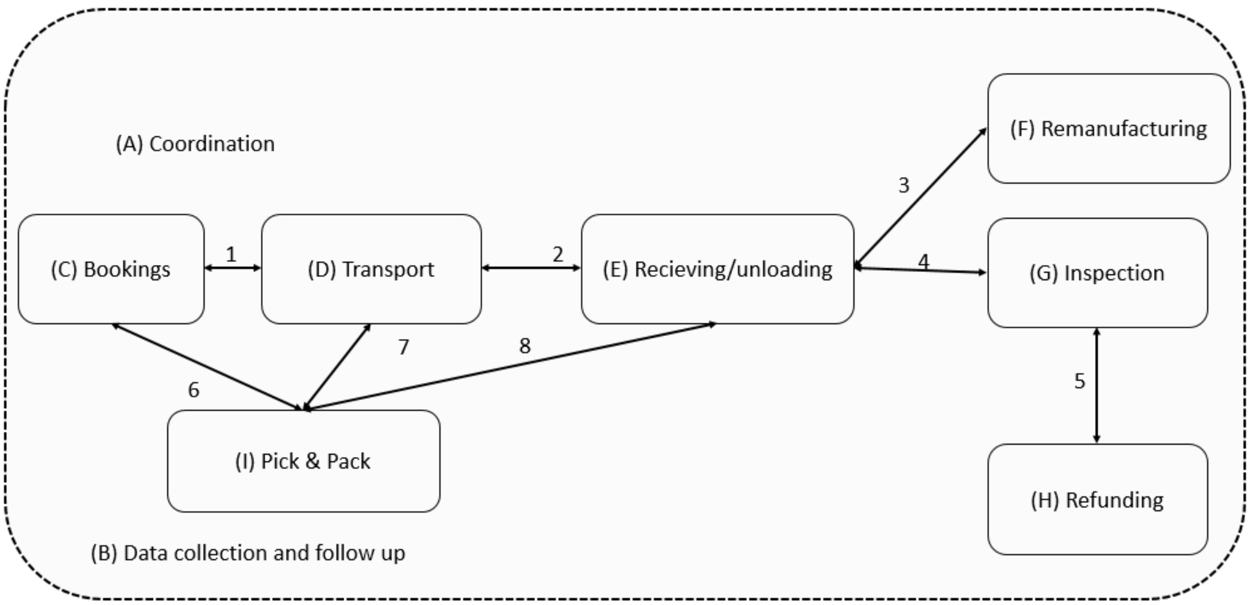

Figure 13. Activity overview

The identified activities can be described as the following:

(A) Coordination: Coordination refers to the process of organizing and integrating the different activities to achieve a common objective. In this case, coordination could for instance mean managing the multiple different activities, so that they function well together.

(B) Data collection: Data collection is the activity of gathering data from the different IT systems, so they are available for other parties that need it. Data collection could come from various methods such as manually inserting data into a system, or that the data is collected when a label is scanned. Examples of data that could be beneficial to collect is what product type it is, where the product is, and how long time a certain activity takes.

(C) Booking: Refers to the activity of scheduling transport and requesting return permissions.

(D) Transport: The transport activity involves moving products from one place to another.

(E) Receiving/Unloading: The process of receiving products that has been transported from one place to another. Unloading means taking the products off a vehicle and place it elsewhere.

(F) Remanufacturing: Means the process of restoring damaged or used products to the condition of a new product. Activities related to this can be dismantling the product, parts replacement, or reparation of parts, as well as reassembling of the product.

(G) Inspection: Means to examine whether a product should be remanufactured or scrapped. Inspection can be done manually or by machines and can also be performed in research purpose by an R&D department. It can also be done to ensure that the returned products are the right products and in the right quality.

(H) Refunding: The process of returning money to a dealer. This process is done when a return order has gone through all previous steps.

(I) Pick & Pack: Means selecting the products that should be transported and pack them in appropriate packaging.

There are three main areas of improvement related to the activities, these are:

- *Requirements*: Means the different needs and the overall aim of the reverse flow. This section focuses on the overall scope of the reverse flow.
- *Processes*: How the different activities are functioning and includes how they could be designed to function in a better way.
- *Design*: Refers to the structure of the reverse supply chain. This section is focused mainly on how different activities are linked together and how suggested changes has been proposed.

In the following three sections, each of these will now be discussed more in-depth.

5.1.1 Requirements

During the interviews, the respondents expressed different views on what the primary goal of the reverse supply chains was. The majority stated that the aim of Volvo SML is to cut costs. The respondents had different views of what to focus on from their own perspective. For instance, an example of this was given by the Logistic Sustainability Developer, who stated that *"While our current operations are heavily focused on cost reduction, particularly in transport, we should also prioritize lead time and emissions."* The person had used a model that measured the relation between costs and emissions and proposed that this could be a more holistic approach to analyze the reverse supply chain. However, the individuals working with transport development tend to focus primarily on cost reduction when sourcing transports, with lead time being another important consideration. The perspectives of the staff working with environment and transport could then be compared to the Project Manager stating, "*We don't need to consider lead time since there is no hurry with the product".* Ultimately, balancing these different objectives is crucial to achieve sustainable and efficient transportation systems.

Gunasekaran et al. (2004) highlight the importance of aligning the organization around the primary purpose of the reverse supply chain, which could for instance be cost, emission reductions or lead times. In the current situation, the main cost driver in the reverse supply chain is the transport activity. The main focus of the transport function has thus been to reduce costs. However, by increasing the focus of the reverse flow towards other objectives such as lead times and emissions, the company can make better use of its resources while reducing emissions as a complement to solely focusing on keeping costs down. This means that the reverse supply chain could be designed in a different way if the focus for instance was on reducing lead times. The increase in the lead time is a result of the numerous activities involved in the activity flow. Various factors contribute to the prolonged lead time for products, including coordinating multiple transportation stages and additional unloading activity. This complexity in operations makes implementing changes within the organization challenging, given the involvement of many actors. As a result of long lead times, Volvo SML is forced to sell new products to the price of remanufactured ones, which results in financial losses. This occurs when they do not have remanufactured products available for a customer's purchase, and thus they end up selling new products at the price of remanufactured ones. Reduced lead time could therefore lead to reduced sales of new products and minimizing financial losses by increasing the sales of remanufactured products.

"*The entire reverse supply chain is designed by adapting to the forward flow, this means that it is not optimally designed for the reverse flow"* expressed the Project Manager. The return products are only picked up once one outbound delivery has been made. If there is not enough space, the cargo will need to wait for the next truck to arrive. The unloading is therefore dependent on the transport activity in the outbound flow. The supplier manager proposed that "*If we want to improve the lead time for the reverse flow, we need to start separating the deliveries from the outbound flow".* The risk with this strategy could be that there would not be any products to transport in the trucks picking up the return products, and nothing to transport back from the dealers in the trucks delivering the outbound products. Therefore, it would be a lot of additional transport that could lower the margins and increase emissions for the transport service providers by driving empty trucks. This type of change could impact the lead time aspect positively but would heavily affect the transport activity in terms of resource utilization. The (A) *Coordination* between the reverse and forward flow would be much harder to coordinate since there would be twice as many trucks as before. This would mean twice as many drivers, and the (E) *Receiving/Unloading* activity would be more complex since there would be a lack of space. Therefore, this activity would be heavily affected by this type of change.

The (B) *data collection and follow up* is an activity that is included in all other activities. This is an area that has great room for improvement. *"One of the greatest issues we have in the return flow is the traceability. We don't know where the goods are. We get claims from dealers saying: Where are our products? It was picked up but no information about when it arrived in Ghent. Nobody knows anything."* – Business Controller. This lack of data makes the activity coordination between all other activities very challenging. For instance, looking at the links between the different activities such as link 1 and 2, they are dependent on information and information is used to coordinate. Another issue related to (B) is the connection between the data collection and the lack of KPIs mentioned above. Since there is a general lack of information in the system now, it is hard to measure how the different activities are performing and what value they bring. By making changes in *(B) Data collection and follow up* activity, it would have opened possibilities to improve their reverse supply chain. By having more data to analyze, Volvo SML can gain valuable insights used to optimize and gain control over its operations and improve activity coordination. This will be analyzed further under the resource analysis since this is related to the IT-systems and the integration between different systems.

5.1.2 Processes

When it comes to the activities within the reverse supply chain, there are some areas that have been highlighted by the interviewees. For instance, one issue that was mentioned was the *(B) Data collection and follow up*. There are scanners used internally by Postnord and by Volvo SML, but the transporting company Galliker does not use this in the reverse flow. It was stated that "*Between the point where Galliker picks up the products at Postnord until the products arrive in Ghent, there is a black hole in terms of information access".* Rather than utilizing scanners, handwritten paper is used during *(E) Loading/unloading*, which is a more time-consuming activity than printing out a label with a barcode and scanning it. The Project Manager proposed a solution of printing one barcode that could be used throughout the entire reverse supply chain. The use of paper increases the likelihood of errors as the activity is more manual, as opposed to if it was printed as a barcode or QR code. This also adds complexity for workers who must have a deeper understanding of what to write on the paper and be able to read others' handwriting.

The *(I) Pick and Pack* activity is another improvement area. Poorly packed products is a big problem. When products are packed poorly, they can be scratched and need to be repainted or scrapped, or the package can be broken so that the products are vulnerable to moisture or other damage. The product could also be sorted poorly by dealers and when this happens, the collector in activity *(E) Receiving* needs to unpack the products and redo the sorting. This shows that the actions of one activity affects the activities of other actors further down the chain. Therefore, it is of great importance that the work is done correctly in the earlier steps of the chain. For instance, if the packaging is done inadequately and the product gets a scratch and it is not discovered until the end of the reverse chain, they need to scrap the products.

Related to the activity *(E) Receiving and unloading* activity, there is a lack information about where the products are as it hinders the receiver of the products from planning their operations. This results in uncertainty and makes it difficult to level the number of trailers volumes. It also impacts the link between *(G) Inspection* and *(H) Refunding* because the refunding activity is dependent on receiving information about that the inspection. If the information flow is poor in the beginning of the reverse supply chain, it becomes even harder to follow the products along the way. The dealers state that "*The only thing we want is to receive our money back as soon as possible".* To be able to (H) *Refund* the dealers as early as possible, it is of great importance that the activity coordination in the steps upstream function correctly. This is due to that the refunding cannot be done until the point where the inspection activity have been performed at the products' end destinations.

5.1.3 Design

Another highlighted area from the empirical studies was the design of the activities of the reverse supply chain with regards to which activities are involved, in what order they are performed, and which actor performs the activities. For instance, there are unbalanced departures from the respective warehouses. The warehouses consolidate (*Pick & Pack (I))* the products and then transport *(D)* the products, which means that the transport is dependent on the previous activities, also including the *Receiving (E)*. The transport *(D)* is optimized in terms of volumes per shipment but not from a lead time point of view, as consolidating products likely leads to extended lead times. It also affects the *Receiving (E)* activities for the actors in the next step since they will have to wait for shipments that could have come earlier. It also makes the volumes greater when they arrive. However, the consolidation has both financial and environmental benefits. One situation where a change in the way consolidation of products is performed could lead to improved lead times is when Galliker uses different transports for different return types. Instead of making consolidation based on return types, the consolidation can be made on all products that are transported to Ghent. From Galliker's point of view, more frequent departures could have been done if products were allowed to be consolidated regardless of which return type it is if these are clearly separated and labeled on the trailers despite having different delivery addresses. The consolidation according to return type is a request from Volvo SML who demands that different return types are transported on separate trailers. However, the lead time for the returns is increasing due to the need of filling up a full trailer for each return type before departing.

A frequently mentioned area of improvement is that return products need to travel the same way in the return flow as in the forward flow. This has been highlighted as adding complexity for the dealers' return activities since they need to keep track of where the products have originally been supplied from. Furthermore, sending the products back to the facility they were supplied from in the forward flow does not create any value considering that they all need to be transported to the CDC in the end. The financial controller suggests alternative solutions for how the activities could be coordinated to generate better customer satisfaction. *"In my opinion, it would make sense that all goods that are picked up at a dealer should be sent to one centralized warehouse and redistributed to the appropriate departments"*. The respondent presents two different options on how to handle the return flows:

1. One option is that all return products should be sent directly to the CDC, instead of first going back to the SDCs and then onwards to CDC for inspection. This would cut one step of transport, as well as one step of performing warehousing activities. Currently, the financial flow is depending on that the products is returned to the sending SDC. To enable the products to go directly to the CDC from a financial point of view, it was suggested that invoices can be sent between the SDC and the customer. This solution would avoid the problem regarding with VATs. Since the VATs currently limits Volvo SML to send the products right to the CDC.

2. An alternative option suggested by the financial controller was to add inspection as an activity at the SDCs, which is currently performed at the CDCs. By moving this activity from the CDC, the time it takes to refund the dealers for the return products could potentially be decreased. It would reduce the workload within the *(G) Inspection* activity at the CDC. Nonetheless, similar volumes would then be divided to the different SDCs instead, resulting in that the SDC would perform the inspection (G). It would also put higher requirements on their resources in terms of staff and space. After the *Inspection (G)*, the products are stocked at the SDC. By doing the inspection at the SDCs a reduction of transports can potentially be achieved. For instance, if a dealer in Sweden makes a return, the product is sent to the SDC in Eskilstuna, then to the CDC. If a customer close to Eskilstuna wants the product it still needs to be transported to the CDC. If the

inspection instead would be performed in the SDC and the product is in good condition, the product could be sent out directly to another customer in Sweden instead of being transported to Belgium and back.

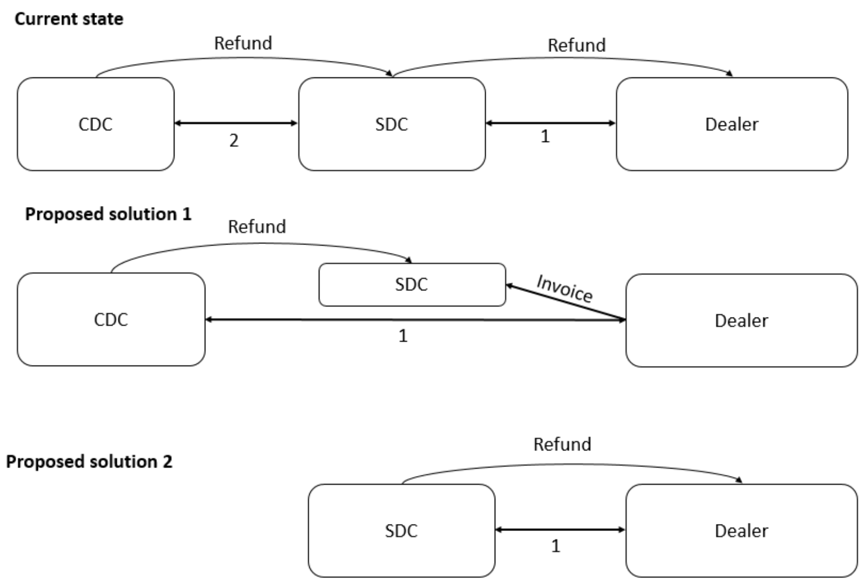

Figure 14. Illustration of the proposed solutions.

5.2 Resource Analysis

There are several resources in Volvo SML's reverse supply chain used to enable the distribution of products from dealers to their end destinations. These resources can be grouped into physical resources as well as organizational resources. The identified resources have been grouped as follows:

Physical

- Products: Automotive spare parts
- Load carriers: Pallets, packaging, boxes, and other containers used for transport, storage, and handling of products
- Vehicles: Trucks, trailers and ships used for the transportation of products
- Equipment: Forklifts, pallet lifters, printers and scanning equipment
- Facilities: Distribution centers, transport terminals and storage/inspection hubs

Organizational

- IT systems: Transport systems, booking systems and warehouse systems
- Employees: People involved in the various activities across the reverse supply chain

5.2.1 Physical resources

When it comes to physical resources, the first type is the returned products that are moved along the reverse supply chain. These products differ from each other both in terms of physical characteristics such as size and weight, as well as administrative characteristics, i.e., return type and brand. The characteristics of products impact both how they can be handled as well as how they are allowed to be handled. An example of how products' physical characteristics impact the return handling is that products need to be packed in the right way to avoid damages during transport, such as not placing heavy and bulky items on top of smaller, fragile ones. The organizational characteristics of the products impacts how efficiently products can be grouped together. While it may seem appropriate to pack smaller items together in the same packages or pallets in the return flow, the fact that products have different return types and delivery destinations can sometimes force products to be kept separate during transport.

Another resource closely related to the products are the load carriers used in the distribution. The products are generally packed in cardboard boxes and multiple products can then be packed in the same box as long as they belong to the same return permission. The boxes are then placed on standard pallets, usually with pallet collars. The pallets used are designed specifically to protect the products as well as to make them easier to handle in the distribution. However, as some products are too large to fit in standard pallets, they have to be packed in alternative ways. This sometimes requires dealers to create their own load carriers which cannot be standardized to the same degree as the pallets. Moreover, the dealers do not in general keep stock of packaging material. The return products are thus often packed in packaging that is left from the outbound deliveries and are therefore not always optimal. Some products are also placed directly in the pallets without any protecting packaging, leading to an increased risk of being scratched or damaged during transport. Since the pallets used in the return flow are the same as those used in the outbound flows, all entities in the reverse supply chain can handle these using their standard equipment.

In order to perform the necessary material handling activity in the return flow, certain types of equipment are needed. The necessary equipment includes printers which are used to print labels to place on the return packaging, including information both about the contents such as product type, return type and order ID, as well as transport labels with barcodes used by the transporters. Other types of equipment are forklifts and pallet lifters used in the warehouses to move pallets, barcode scanners to scan the printed labels, and scales to weigh the products.

Lastly, the physical resources in the reverse supply chain include facilities. Facilities refers to dealer shops, distribution centers and hubs, which have different uses in the chain. These facilities also have different objectives when it comes to the outbound and reverse flow. In the reverse flow, the CDCs are used to keep stock of products as well as to perform inspection and other material handling activities. SDCs are, in the reverse flow, mainly a consolidation point where return products arrive from many different dealers and are shipped out together to a CDC. Similarly, carrier hubs are used as consolidation points where return products are grouped together to allow for higher fill rates in vehicles used in the transportation. Warranty hubs are mainly used for inspection of products and core hubs are used for both inspection as well as consolidation of products going to remanufacturing. One important factor when it comes to the facilities in the reverse supply chain is that they have enough capacity to handle the product volumes. This is sometimes an issue at the core- and warranty hubs which sometimes receive more products than they can store in their warehouses. The Core Technical Manager states "*In Ghent we have 720 sorting pallets today which are placed in different pallet racks around the hub. That is too much. It is a challenge because we do not have enough space for more pallets than that*".

5.2.2 Organizational resources

One of the most crucial organizational resources in the reverse supply chain at Volvo SML are the IT systems. These systems allow for communication between entities in the chain and are a requirement for performing some of the activities related to the returns. IT systems are used by the dealers both to request permissions for making returns, as well as to book transports from carriers. Moreover, they are used by carriers to keep track of the products in transport, as well as by other entities to keep track of what they have in stock, and what is in their pipeline. Currently, there are multiple IT systems in use at Volvo SML which are used for different things. For instance, booking of returns and transports are made in separate systems and the systems used to register returns differ among return types. Furthermore, the internal return systems and the transport system are not connected to each other, and each operates in isolation. There is thus no ability to follow the returns in transit since there is no connection between the internal order ID at Volvo SML and the transport ID used by the carrier. Related to this, since Volvo SML and the carriers use different identification numbers in their operations, there are no common barcodes which can be scanned to send out information about a return order and its corresponding shipment.

Another organizational resource within the reverse supply chain is the people performing the different activities, i.e., the employees. Much like the capacity at the facilities, the working capacity of the employees is also important for keeping the reverse flow functioning. This has been found to be an issue in some areas in the reverse flow, for example at receiving facilities where the bulk of unloading activities must be performed during hours where there is enough staff available. Another finding connected to the employees in the return flow is that many of the activities are highly manual. For example, the transports going to Belgium which are handled by PostNord during the first leg of the transport have their end destination marked on the packages even though PostNord does not perform the transportation all the way. This means that the employees working at PostNord need to know that these packages need to be handed over to Galliker to take care of the remainder of the transportation without it being explicitly stated on the packages. The more manual activities there are, the higher the potential risk is for human errors causing disruptions in the flow. Moreover, due to the complexity of some of the activities related to the booking of returns, having competent personnel at dealers is of high importance to ensure that activities are performed correctly.

5.2.3 Areas of improvement related to resources

From the resource analysis, it has been found that Volvo has access to most of the resources needed to achieve a well-functioning reverse supply chain. Only a few areas where there is an insufficient availability of resources has been found. This includes that dealers do not always have access to the proper packaging materials when sending back return products, as well as that some actors do not have access to scanning equipment. There are however attributes of some of the resources that impacts the total resource utilization and coordination in the reverse supply chain.

The physical products currently have some restrictions on how they can be handled due to previously mentioned characteristics such as return type. The fact that products with different return types are not currently allowed to be mixed with each other during transport leads to potential inefficiencies in the resource utilization of both load carriers, vehicles, and facilities. Since different return types in some cases cannot be co-transported, it leads to increased risk of needing to send half-empty vehicles in case certain lead times need to be achieved. At the same time, if lead times are not a priority and all products will wait at the different facilities until there is enough volume to fill up a full truckload, there will be a high occupation of space at the facilities while products are waiting to be dispatched. If products were allowed to be mixed in transport, potential improvements in fill rate of vehicles and space utilization at sending facilities could thus potentially be achieved as long as the products have the same, or adjacent, final destinations.

When it comes to the coordination of resources within Volvo's reverse supply chain, the IT systems have been found to an area where potential improvements can be made. While it seems that all actors have access to the systems required to be able to perform their activities, the lack of integration between them makes communication and data sharing between actors more difficult. In order for all actors within the reverse supply chain to be able to plan their activities as efficiently as possible, they are dependent on information from other actors. From the empirical study, it was found that the workloads at receiving facilities are highly affected by both the volume and type of incoming products. To enable these actors to determine their staffing requirements as well as better schedule at what times the deliveries can be made, more information about the incoming products is essential. Another frequently mentioned request is for dealers to be more updated on the status of their return orders as well as to trace products that get lost. This too requires a better information sharing between actors involved in the reverse supply chain than what is currently in place. As previously discussed, these improvement areas are not so much as consequence of that the proper IT systems do not exist. It is rather a consequence of the inability of these systems to communicate with each other.

5.3 Actor analysis

The main actors in the reverse supply chain are presented in figure 15 below. The actors have been divided into four different main categories A-D.

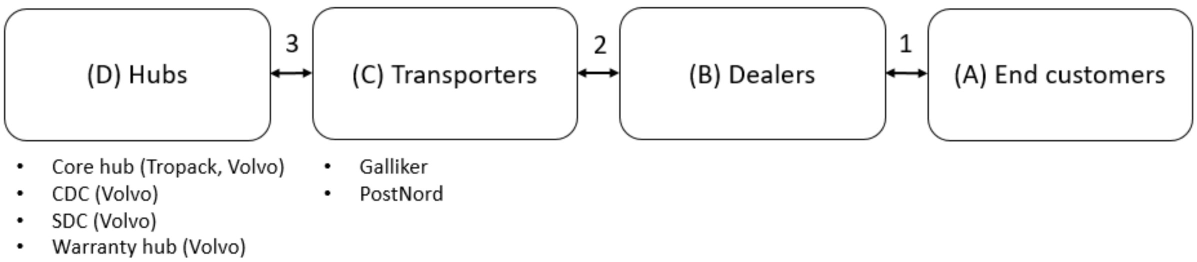

Figure 15. Overview of the categories of actors.

5.4 Actor-Resource analysis

The main links between different actors and resources are presented in Figure 16 below.

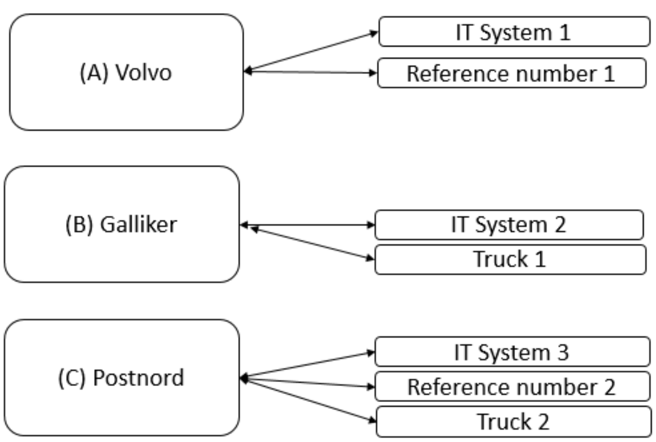

Figure 16. Visual representation of the links between different actors and their resources.

Presented above are the different interfaces between different actors and their respective resources. As mentioned before, both Volvo SML, Galliker and PostNord have different IT-systems that they handle the products. They also use different reference numbers for the shipments, and Galliker and PostNord use their own trucks to transport the products. The issue here is that they have different systems for each carrier. Volvo SML has tried to develop solutions for the outbound flow called Volvo Precision that should act as a bridge between the different systems they have. The issue with this system is that it has taken several years to implement it for only two different flows. Therefore, it would be very time consuming to do the same for all different flows in the reverse supply chain as well. Volvo Precision is designed to act as a bridge between Volvo SML's system and the transporting companies' system When designing Precision, Volvo SML's decided what information they needed in the system from the transport operators to get full visibility in the system. Volvo SML receives a reference number in their own system, resulting in full visibility throughout the reverse supply chain. The picture below is a visualization of how Volvo SML could design their information structure to give full visibility by using Volvo Precision.

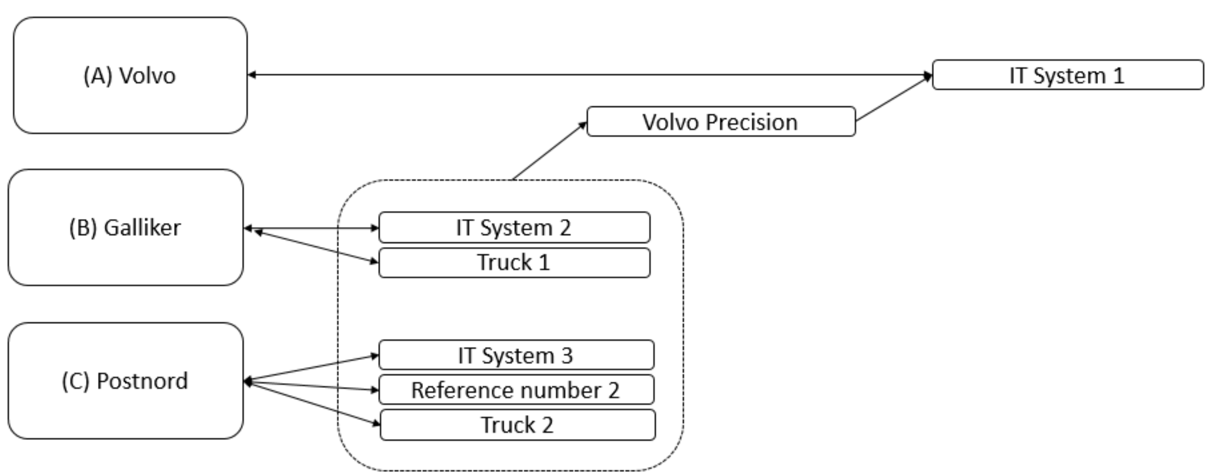

Figure 17. Illustration of how Volvo Precision could work for the reverse flow.

By decreasing the number of actors there would be fewer links and therefore decrease the complexity in the reverse supply chain. This would result in that it would be easier to implement and make changes for the reverse supply chain. The complexity of the current setup limits the ability to make changes. It makes changes more complex to implement and to assess different options. It is easier to make adaptions to a more agile and smaller system than a system containing a very high number of different actors. One proposal made by the Project Manager would be to look at only using one carrier. That would reduce the flow with two links, making it smoother and easier to implement changes.

5.5 Actor-Activity analysis

In the Volvo SML case, there are multiple actors that perform the same type of activities. For instance, transport activities handled by different firms and material handling occur at many stages of the flow. This is necessary due to the complexity of the reverse supply chain, but it also leads to additional activities. By changing the activity structure, the company could improve its activity coordination and resource utilization. A possible approach to achieve this would be to analyze the resources or activities that do not contribute to shortening lead time but only serve the purpose of cost reduction. There could be options that serve both these means as well. By identifying and eliminating such activities, the company can reduce the number of activities and achieve better lead times as well as resource utilization and easier coordination of its activities.

For instance, since PostNord handles the first leg of the transport from the reseller to their hub, they need to first load the products, then unload the products and sort it. Then Galliker picks up the same products, transport it and consolidate it into different shipments. This lead time could potentially be shortened by only using one transporter since it would reduce the total time to receive and unload in half since it would be done one time instead of two. Currently, it is done by both Galliker and PostNord, meaning the time could be reduced if only one of them performed the activity. It would also ease activity coordination of the reverse supply chain, due to fewer actors.

The case above with Galliker and PostNord is just one example of two actors that work with the same type of activity. They both try to achieve great resource utilization and activity coordination, but since they have different ways of handling the same type of task it makes it more complex for Volvo SML. For instance, Volvo SML has stated that they want to achieve better information flow, and since they are dependent on multiple actors, with different IT-systems and ways of handling the products, it makes it complex for Volvo SML to achieve a good overview of the flow.

From the point where the dealer books the transport of a return product, to the point when it arrives at the PostNord hub, Volvo SML can track the location of a product. By only using PostNord for instance, it would be possible to have this type of visibility all the way until the product reaches the sea transport leg to Ghent. By only having one transporting company it would be easier for Volvo SML to put requirements on what information they need when they do their transport sourcing. For instance, one case was presented in UK where they only have one Transporting company, Maxi Haulage *"What we did was that we put pressure on them that we need a certain type of visibility in our system, so we developed a solution in collaboration with them that would work for both them and us. They know what information we need in our system and now we have great visibility within that area segment".*

For instance, there is a gap between the time when a dealer receives a return permission and the time when they book the transport where Volvo SML has no knowledge about how long time it takes. Another time gap is between when the return products are delivered in Ghent by Galliker, and until the boxes are unpacked. "*Currently, the products could stay in the hub for 30 days and we only know the time from when the box is opened until it is inspected".* By using one transporter or putting greater pressure on the transporting companies on what information Volvo SML needs, it would be easier to get an overview of when the dealer received the return permission, until the end of the reverse supply chain.

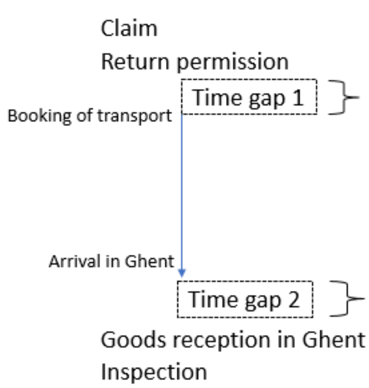

Figure 18. Visualization of gaps.

The alignment between the activities that are performed, and the respective responsible actors are lacking today. Currently, each actor take responsibility for their activity, but the overall resource utilization isn’t optimal such as the use of staff and trucks etc. The different actors are treating their activities as separate and focusing on performing their internal activities well instead of focusing on an overall performance. However, the actors in the reverse supply chain are also involved in other reverse supply chains they need to take into consideration. This means they need to both work with improving their sequential interdependency with Volvo SML but also take horizontal interdependencies into consideration. By visualizing the overall performance and use data that is available for all activities summoned in one system, it would be easier to see areas of improvement. For instance, if it takes two days for a dealer to book a transport and the product waits in Ghent one week until it is processes it will take 7 extra days until the dealer gets their money back.

5.6 Activity–Resource analysis

When it comes to the interplay between activities and resources in Volvo SML’s reverse supply chain, the most prominent issue is how their IT systems impact how some of the activities need to be carried out. This is perhaps most notable on the dealers’ end of the return flow. Here, due to the existence of several different IT systems as well as some of the systems being quite outdated, some activities become both complex and time consuming. One example of this is the lack of a connection between the dealers’ internal warehousing systems and the systems in which the returns are registered. When a dealer registers a return in their return systems, they then must manually deduct the returned quantities from their stock levels in their warehousing system. This gives both an extra activity in the return process, making it more time consuming, as well as a risk of the warehousing system showing inaccurate stock levels for some products. A scenario that could arise from this is when a return is made on a product with a time delay from the point it is registered in the return system until it is deducted from the stock levels in the warehousing system. Between this point, a customer could be promised a product which is in fact not available for purchase. If there was a link between the systems giving an automated update on the stock levels based on the registered returns, problems like these could be eliminated, as well as reducing the number of activities required to perform in the dealers’ returns.

Another aspect related to the interplay between activities and resources from the dealers’ perspective is the lack of necessary equipment available to improve some of the activities. Currently, a lot of the activities are highly manual which leads to increased time consumption and risk of human errors. An example of this is that when registering products into the IT systems, both when registering a return as well as when adjusting stock balances, the article numbers of the included items need to be inserted manually into the system. As mentioned by a dealer employee "*Volvo SML usually has very similar article numbers for items in the same product categories. If I type one number wrong into the system, I might adjust the stock balance for the wrong product*". Apart from the risk of making errors in the systems, having to manually insert all article numbers one by one has been found to be very time consuming for the dealers in their return handling. The more products are being included in a return order, the more time consuming it becomes, and the dealers thus risk wasting a lot of time on the return handling. If the dealers had the ability to scan products, e.g., with barcodes, these processes could likely be performed significantly faster without the risk of human errors causing problems. Today, the dealers do not have the ability to do this, both because they do not have the right scanning equipment, but also because the IT systems do not currently support this.

Another issue that has been found regarding the connection between resources and activities in Volvo SML's reverse supply chain is that the current availability and utilization of resources limits the ability to perform follow-up activities. There is, as previously mentioned, a lack of integration of the information systems used by the different actors in the reverse supply chain. This lack of integration leads in some cases to a decreased ability of collecting the data necessary to make proper analyses on the performance of the activities. For example, the lack of a connection between Volvo SML's internal return systems and the transporters' IT systems needed to track the transports of specific return orders has been shown to leave information gaps throughout the reverse chain. These information gaps lead to that data regarding the process time of certain activities is incomplete, and not detailed enough to draw relevant conclusions from it. It is currently possible to analyze lead times for example between the point when a dealer places a return order until they receive their refund. That information does not say much however since it is not possible to go into detail and analyze in what parts of the reverse chain the lead time deviations occur. It could be for instance that the products are kept at a transport terminal for a long time, but that will not show in the data. By scanning products or packages when different activities have been performed, or when an order has reached a certain stage of an activity, the collected data can be analyzed to find where in the return flow bottlenecks can be found, and which activities are likely to cause lead time deviations.

A problem area in the return flow that has been frequently highlighted by the interviewees in this study is that the lack of traceability of return orders makes it difficult to handle situations when orders get lost in transit. Due to the absence of status updates of orders along the reverse supply chain, it is difficult to investigate where in the processes the orders have been located, and thus what could potentially have happened to them. The increased traceability that could be achieved from integrating the IT systems of different actors could thus enable better possibilities of investigating the root causes of lost transports. Additionally, increased traceability could improve the ability of collecting data on the frequency and impact of lost transports. Although lost products have been a frequently discussed topic among interviewees, there seems to be a lack of consensus regarding how big of a problem it is throughout the organization. Thus, by being able to better analyze how often such events occur, as well as their financial impact, a better understanding could be achieved of how much effort should be put towards solving the problem.

6. DISCUSSION

In this section, a discussion about the empirical findings and analysis will be presented. It will act as a basis for the recommendations given in chapter 7. The three areas that will be discussed are: Supply Chain Structure, Supply Chain Visibility, and Goals and Key Performance Indicators.

6.1 Supply Chain Structure

Currently, the structure of the reverse supply chain is designed based on how the forward supply chain functions. The rationale behind this is that Volvo SML have higher volumes in the forward flow and have historically wanted to keep the costs down for the reverse flow. People within the company has highlighted the concern regarding whether it is worth changing the structure or work with improving the reverse flow. Changing the structure of the outbound flow to improve the reverse flow will likely not happen since the outbound flow is financially more important for Volvo SML. However, it could be possible to make changes that doesn't affect the forward supply chain.

One option could be to separate the outbound flow from the reverse flow. This could result in a whole new structure and freedom to design the reverse supply chain without having to account for how it impacts the forward supply chain. One frequently mentioned issue in the reverse flow which has arisen from that the reverse flow is adapted to the forward flow is that return products need to be transported the same way in the reverse flow as in the forward flow. This has been found to not generate any benefits given that all return products end up in the same end-destination regardless of how they are transported through the reverse supply chain. By designing the reverse supply chain separately from the forward supply chain, these forced transportation routes could be eliminated. By not having to transport products to different locations, a higher resource utilization could be achieved by allowing dealers to consolidate return orders regardless of where they have been supplied from. Thus, the risk of sending half-empty pallets as well as having multiple pickups being made at the dealers' facilities to ship the same number of products could thus be reduced. A change to the structure like this one would however require the implementation of new activities in the reverse supply chain. One solution is to implement inspection processes at the SDCs in order to put return products back into stock without having to send them back to a CDC. By doing so, the transport for the return products between the SDC and CDC could be eliminated. Another option is to allow dealers to generate invoices for their return products in order to circumvent the current issue of VAT legislation that restricts them from sending products back directly to a CDC regardless of how they were supplied in the forward flow. By using the latter option, all return products from dealers could be consolidated in the same shipment, and once they return to the CDC, they can be redistributed to where the demand is in a much larger area than what is covered by an SDC.

Another consequence of designing the reverse flow as an adaption to the forward flow is that there are currently multiple carriers used for the transportation activities in the reverse supply chain due to the fact that these are used to perform these activities in the outbound flow. Given that the outbound flow has been of higher importance in the company historically, efforts have been made to ensure a sufficient activity coordination between these actors. Since the reverse flow has previously been given less attention than the outbound flow, the same degree of coordination has not been achieved. One possible solution to improve the activity coordination is to reduce the number of carriers in the reverse flow. This would make it simpler to coordinate the activities performed throughout the reverse supply chain due to a reduction of actors and corresponding resources in need of coordination. However, assessments should be made on what implications a change like this would have on other parameters such as costs. Additionally, the general impression within Volvo SML is that the coordination is functioning well in the forward flow using the same carriers. A similarly well-functioning system would likely be possible to achieve in the reverse flow as long as enough resources are put into it.

Although the forward flow has historically been considered more important than the reverse flow, the trend in society moves more towards sustainability and circular economies. A prediction is therefore that more products will be remanufactured in the future. This would mean that the reverse flow could potentially be almost as big as the outbound flow. For instance, all batteries need to be retrieved due to the materials they contain, but also due to the possibility of remanufacturing the products. This will create large volumes both in terms of weight and number of units, but also in the tied-up capital for products located in the reverse supply chain. This means that more products in the reverse flow will have higher value and that the importance of a system with great resource utilization and activity coordination will be crucial. By changing the structure, Volvo SML could achieve this by using different actors as well as changing the activity structure. These changes could also result in reduced emissions, bound capital as well as the risk lost products.

6.2 Supply Chain Visibility

Volvo SML has described a need to improve their overall visibility for all parts of the reverse supply chain. Today, the visibility in the reverse supply chain differs a lot between the different parts. In some parts of the reverse supply chain, such as the part where PostNord has the responsibility over the products, it is possible to track the products whenever they have reached a new step in the return process. When Galliker takes over the responsibility of the products there is a significant reduction in visibility, meaning that there isn't any information available about where the products are. However, there is a general lack of information sharing within the reverse supply chain, even though some actors have information that could be beneficial for others to have. The reason for this is that there is problem among the interfaces between the firms. Three different alternatives will be discussed about how Volvo SML can change the visibility in their reverse supply chain.

The first option could be to implement scanners through the entire reverse supply chain, from the point of dealers until the products are back in the outbound flow. There exist scanners at dealers, PostNord and at Volvo SML's warehouses, the only actor that lack this resource is Galliker. In order to perform the scanning, dealers would also need to be able to generate barcodes corresponding to the return permission number that they currently attach to the return products. The problem is not only related to the lack of scanners but also from the utilization of available data. Improving the visibility related to Galliker involve advocating for the implementation of scanners. This can be done as part of the sourcing process when setting up agreement terms and would result in that the essential information is captured in their system. Galliker would be able to scan the products when they pick them up at PostNord's warehouse and when they have made the consolidation. The scanning could be done on Volvo SML's barcode and then it would be possible to see in Volvo SML's system where the products are located. The challenge lies in the fact that implementing scanners would necessitate new activities and investments in new resources for Galliker. However, today they keep track of the same type of information, although the process of collecting that information is much more manual. This change could potentially make their work easier, and when errors occur, the possibility of investigating where in the process things have gone wrong would be greatly increased. The change would require Galliker to update their IT systems and use barcode scanners such as hand computers to scan the goods. This could be a first step to get better visibility in that part of the reverse supply chain.

The second option that could enhance visibility but also entail greater complexity regarding implementation compared to focusing on Galliker's resources, would be to implement a solution like Volvo Precision. This solution would mean that the transporting companies would keep their old systems but use their identification number of the products and connect them to a cloud solution, so Volvo SML would receive all the information in their system, but the transport operators use their own ones. The limitation with this solution is that it has taken multiple years to implement for two other outbound flows. The benefit is that the transport companies would not need to do any changes to their current IT systems.

The third option to accomplish better visibility could be that all parts of the reverse supply chain should use the same barcode. At the dealer, they currently print out labels for PostNord containing their barcode and for Volvo SML to keep track of the products, they use handwriting on a printed paper. A more efficient solution would be to create a Volvo SML barcode that could be used by Volvo, PostNord and Galliker. This could be printed in the same way as PostNord does today. However, it is assumed that PostNord would still want to use their internal barcode, and then two similar printing labels could be made containing the right information. In this setup, when a return permission is given, the dealer prints out both PostNord and Volvo SML barcodes and attaches them to the product. Then, they will scan the Volvo SML barcode to send out information to their systems that the products have been prepared for transport, and the products are then shipped with PostNord. At all times where Postnord scans the products, i.e pickup, delivery, and pickup by Galliker, they scan both codes. When the product arrives for instance at Galliker they scan them, and then when the products are consolidated for shipment, they scan them again. This would enable Volvo SML to receive status updates whenever an order reaches a new step in the transport process. An extension of this could be to give the receiving facilities the ability to scan these products as well. That would give updates on when the products have been received by the different hubs around the reverse supply chain. Having information about the times when products reach new steps of the return process would not only give the ability to see where the products are located, but also to analyze other performance measures such as the lead times for different activities as well as the total lead time for the entire return process. Furthermore, this would enhance the opportunity to consolidate products, leading to improved resource utilization.

6.3 Goals and Key Performance indicators

The goals of an organization play a critical role in understanding in which direction the company should pursue moving forward. KPIs is a way to track and measure the progress in relation to these goals and make it easier to work with improvement areas. The main target for Volvo SML when performing different activities has been described as to keep the costs down. However, it has been shown that the main target differs between the different actors involved in the reverse supply chain.

Low effort has been put into visualizing vulnerabilities within the reverse supply chain by using KPIs. One reason for this could be the lack of information discussed above. By utilizing more accurate information, Volvo SML would find it easier to align KPIs and compare them against the organization's overall objectives. More accurate information means that the information received is reliable and precise. However, this could also lead to realizations that would require changes within the structure of the reverse supply chain. The question remains to which cost the company are willing to change its operations to improve other KPIs as well. There is currently a sense of uncertainty within the organization regarding which KPIs are the most important today and how the relationship between for instance costs and emissions, should be defined.

If Volvo SML wants to become climate neutral by 2040, they need to make adaptions today. Therefore, it is not enough to solely analyze current costs, but to also prepare for the future. Defining the KPIs they wish to focus on today becomes critical to align and meet their long-term goals (10-20 years). Many of these implementations will take a long time and therefore it is important to start working with this now. Nevertheless, the absence of appropriate information in the reverse supply chain prevents the establishment of suitable KPIs, as they rely on the flow of information. One way for Volvo SML to work towards their long-term goals is to analyze parts of the reverse supply chain that do not align with their vision and thereafter, changes can be made accordingly to steer the organization towards its desired objectives.

7. RECOMMENDATIONS

In this section, recommendations are provided on how Volvo SML can change their reverse supply chain to improve resource utilization and activity coordination. The section is divided into three areas: Supply Chain Structure, Supply Chain Visibility and Goals and KPIs.

Supply Chain Structure

As a first step towards restructuring the reverse supply chain, a recommendation is to remove the forced transport routes that require products to be transported the same way in the reverse flow as in the outbound flow. Out of the alternative solutions presented in section 6.1, it is recommended that all return products are sent directly to the CDCs instead of transporting some of them through an SDC in the return flow. This is assumed to generate decreased transport costs and to potentially reduce the environmental footprint from Volvo SML's transport activities. Additionally, the restructuring would simplify the return processes for the dealers as well as enabling increased resource utilization stemming from increased consolidation of shipments. The increased resource utilization is expected to be a consequence of having more frequent transports to the same destination. More frequent departures can potentially lead to shorter times for accumulating full truckloads of products which in turn can lead to higher fill rates in the transport vehicles. Furthermore, less occupation of space can be achieved at some of the facilities in the reverse supply chain. By eliminating the receival of return goods at the SDCs, the space at the warehouse can be used for other purposes. Additionally, dealers do not need to have separate storing areas for return products that are going to the different distribution centers.

In the long run, it is recommended to evaluate the possibility of redesigning the entire structure of the reverse supply chain to get ready for higher product volumes and to adapt to sustainability requirements in alignment with Volvo Group's overall aim. This should be done by considering both the forward and reverse flow chain when establishing the structure of the entire supply chain in order to achieve the best total performance of both flows while still being able to combine resources between them. In the near future, it is expected to be an increase in remanufactured products and batteries in Volvo SML's reverse supply chain. These products are often of high value which makes them contribute to large amounts of tied-up capital when in storage or transport. To adapt to higher product volumes and products with higher value, it will be increasingly important that the reverse supply chain has short lead times, is cost efficient and sustainable. The reason why shorter lead times would be more important is because there will not be enough batteries produced to meet demand and therefore, they will need a fast reverse supply chain to be able to sell remanufactured products. The reverse supply chain needs to be sustainable to meet Volvo SML's long term goals related to sustainability and cost efficient to be profitable. To achieve this, it is considered necessary for Volvo SML to put more emphasis on the reverse flow in the future when structuring their supply chain.

Supply Chain Visibility

The visibility has been found to be one of the currently most prominent areas of improvement in Volvo SML's reverse supply chain. In order to improve the visibility and flow of information, some actions are recommended. As a first step, Volvo SML should create an internal barcode that should be used by dealers and the involved transport service providers. Implementing this would require equipping all actors with resources such as scanners to collect necessary information. In this first step of improving the visibility, it may not be necessary to implement a solution with real-time package-level tracking of the shipments. What is most important is that all actors collect information about when a product goes through a certain process or reaches a new destination in the reverse flow. What is lacking today is the ability to follow the products when they are exchanged between different actors, and by demanding that all actors collect information connected to Volvo SML's internal order numbers, the information sharing can be greatly increased. Although this level of visibility would not allow for any real-time tracking of products, the information exists to be accessed by Volvo SML or any of the other actors involved in the reverse supply chain when the need arises. This information can then be used e.g., to trace lost products, or to evaluate the lead times for different processes throughout the reverse flow.

As a second step, a more continuous exchange of information between actors is recommended. This means that all information should be available in the same system and be automatically updated when new information is collected. Here, the goal is for Volvo SML to use their own internal IT system and have it linked to the external systems used by the transporters. A challenge with this solution is that there needs to be a bridge between the IT systems used by different actors that can send and transform the information to a common platform in a common format.

This has previously been done in the outbound flow at Volvo SML using a system called Volvo Precision as the bridge. Here, all actors will still use their own systems to collect information, but Precision makes it possible to merge the information together to make it accessible from one source. A similar solution is thus advised to implement in the reverse flow in order to allow for more easily accessible information about where the return products are located at certain times. This is expected to result in better activity coordination between the different actors in the reverse supply chain by enabling them to follow the products. By having information about what products will arrive in what quantities to the receiving facilities in the reverse flow, better planning can be performed in terms of staff allocation. Moreover, having historical data on the quantities delivered to different locations at specific times can be used to assign time slots for when deliveries should be made at the facilities. Improved information accessibility could also improve resource utilization by enabling improved consolidation options. By having information about what orders are expected to be received at different terminals and hubs, orders can be better matched with other ones that are going to the same destination.

Goals and KPI's

To address this issue, it is recommended to establish and set more clear goals to specify what the aim is both in the short and long term for the reverse supply chain. These goals should be defined by using a higher degree of information sharing between actors to identify and evaluate the appropriate KPIs. With improved clarity on the purpose of the reverse supply chain, the organization can make better decisions and avoid conflicts of interests by having some common KPIs for all actors in the chain.

The KPIs that are proposed for Volvo SML are:

- **Life Cycle Emissions:** Volvo SML has data about the emissions of parts of their reverse supply chain, but the emissions are not integrated enough in their strategic decisions. By implementing and using this, they will be more likely to reach their long-term goals. Within the Greenhouse-gas Protocol, scope 3 emissions include emissions that are not caused by a company itself, but by other actors in the company's supply chain. Hence, to become climate neutral, Volvo SML needs to have knowledge about the emissions of all actors in their reverse supply chain. By increasing the degree of information sharing between actors and their activities, emission data can be calculated and used to evaluate what actions are needed for Volvo SML to take towards reaching their sustainability goals.

- **Costs in relation to emissions:** By comparing transportation cost in relation to emissions, Volvo SML can establish a KPI that enables them to compare different reverse supply chain activities not only in terms of cost, but also in terms of their environmental impact. For instance, this could lead to that one transport solution is preferable in terms of transportation cost, but not in terms of emissions. Moreover, some products do currently not have enough monetary value to justify the associated logistics costs for returning them. By weighing the cost and emissions of scrapping and reproducing such products against the cost and emissions from return transports, Volvo SML make more environmentally sound decisions. Thus, by incorporating both cost and emissions into a single KPI, Volvo SML can gain an overall understanding of how a decision affects the company, ultimately helping them achieve their targets both related to transport costs and emissions.
- **Delivery precision:** Delivery precision is a way to help Volvo SML secure that the right products arrive at the right time. Delivery precision is used today within the organization but has not been identified as one of the main KPI's within the return flow. An issue that has been frequently highlighted by actors in the reverse supply chain is the uncertainty regarding when products will be delivered. Fluctuations in delivery times also cause uneven workloads at various facilities throughout the reverse flow. By focusing more on the delivery precision in addition to other KPIs such as lead time, it could potentially make the work smoother and more predictable at these facilities.
- **Lead time:** A need has been described to see the lead time for different parts of the reverse supply chain. Here, the lead time refers to the time it takes to perform an activity such as a transport or sorting activity. By achieving better visibility within the reverse supply chain, Volvo SML can analyze the lead time each activity on its own, as well as how it impacts the total lead time from order registration to refund receival. Moreover, by identifying activities that are subject to long or fluctuating lead times, improvements can be made. Having more data available on when an order reaches different steps throughout

the reverse supply chain can also ensure that all lead times are correctly measured and that individual actors do not measure lead times only to satisfy their own targets.

By implementing these recommendations, Volvo SML can develop a reverse supply chain structure that will be ready for future increases in product volumes in the reverse flow. Additionally, they can achieve better visibility within their reverse supply chain which can facilitate the decision-making and usage of KPI's. It will thus enable Volvo SML to reach their long-term goals since they will be able to compare how they are performing today in relation to their goals. From increased awareness on the current performance in relation to the desired performance, the right actions can be taken to ensure that the reverse supply chain will perform as efficiently as possible in the future.

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