Transportation Costs in Centralized and Decentralized Structure

- A case study at Rottne Industri AB

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____________________    ____________________    ____________________
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Abstract

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Title: Transportation Costs in Centralized and Decentralized Structure - A case study at Rottne Industri AB

Background: Rottne Industri is a Swedish heavy machinery manufacturer whose production process is divided in three manufacturing plants. The production takes place in the facilities of Stensele and Lenhovda while the one at Rottne is also used for the final assembly. Ten suppliers provide steel materials to each facility translating to relatively high transportation costs which may be reduced by adopting a more centralized structure.

Purpose: The purpose of this paper is to identify the transportation costs between the steel suppliers and the three manufacturing plants at Stensele, Lenhovda and Rottne as well as the freight transportation costs for components from Stensele and Lenhovda to Rottne. Moreover, the research seeks to analyze the difference in transportation costs if Rottne Industri was to centralize all its activities into one single manufacturing facility at Rottne. Finally, the authors aim to identify the environmental cost related to freight transportation in order to evaluate the total transportation cost difference between the two scenarios.

Method: The Master thesis focuses on an instrumental case study on a single company. Qualitative and quantitative research methods are used for the necessary data collection to bring up a broader picture of Rottne Industri transportation costs and how it will change in a different organizational structure.

Results: The studied company would reduce its freight transportation cost from 2 471 735 SEK of the current decentralized structure to 398 265 SEK of the centralized one. The environmental cost would decrease by 91% (20 420 SEK) due to the decrease of material flow. Therefore Rottne Industri would reduce its total transportation costs by 84% by centralizing its manufacturing structure, for a monetary value estimated at 2 095 860 SEK. However these results contradict part of the theoretical framework concerning the advantages and the disadvantages of centralization and decentralization, as the new centralized structure appears to be more easily manageable while reducing the transportation costs from the different suppliers. Therefore further researches are required as a broader approach on the effects of switch in the organizational structure at Rottne Industri.

Key words: transportation costs, material flow, activities mapping, centralized structure, decentralized structure, freight transportation, manufacturing company, environmental costs.
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1. Introduction

This chapter introduces a general overview of the studied area with a presentation of the company object of the case study. A problematization of the topic is then made in order to produce three research questions and define the purpose of the research with the related limitations.

1.1. Background

The study focuses on Rottne Industri, a privately owned Swedish small-and-medium size enterprise (SME) whose headquarter is based in Småland at Rottne. Its main activity is the manufacture of heavy machinery for the forest industry with a product range divided into two categories: harvesters and forwarders (Axelsson, Sales Manager Export, 2013). The company possesses several manufacturing facilities within Sweden (Rottne, Lenhovda and Stensele) in which 235 workers are employed (Rottne.com, 2013). Rottne Industri’s production is split into its three different manufacturing plants with the final assembly line being located at Rottne. The company produces all its components internally from raw materials with limited outsourcing (Axelsson, Sales Manager Export, 2013).

As a manufacturing company, its core function is to convert inputs such as materials, labor and energy into outputs like products (Hill, 1993). A manufacturing organization, in order to be competitive in performing this core activity, has to develop the most appropriate tools and methods that fit its organizational and strategic requirements (Voss, 1995). Most businesses often combine two or more of process layouts in order to manufacture their products and the choice of the appropriate process is driven by market characteristics, volume of output to produce and the nature of the product (Hill, 1993). It in turns leads to management decisions concerning whether centralizing or decentralizing their organizational structure (Bolander et al, 1999; Voss, 1995).

Today geographically dispersed market often calls for a decentralized organizational structure for closer proximity with the customers’ requirements as well as the inputs of relevant benchmarking of local competitors to improve the overall processes taking place in the organization (Kouvelis and Gutierrez, 2001). Decentralized organizational structures often prove to provide greater flexibility considering whether managers choose to adapt the
different activities into different business units to create greater cooperation and sharing of information for future improvements (Jonsson, 2008). A decentralized organization is often used by companies with the purpose of enhancing informational and organizational efficiencies (Bolander et al., 1999).

However, one of the principal challenges in operating in decentralized system is to evaluate the costs of logistics activities when the different segments of the company interact (Anthony and Govindarajan, 2007; Bolander et al., 1999). When it comes to considering whether to centralize or decentralize the organizational structure the flow of materials in the logistics system is of particular importance. The flow of materials consists of three main functions: transportation, handling and storage of goods (Jonsson, 2008). Freight transportation deals with the transport of goods between different plants, while material handling refers to the internal transport and handling of goods inside a facility. The link between transportation and material handling is storage as the flow of materials usually goes to and from a storage location (Ballou, 2003; Jonsson, 2008). Managing the logistics activities included in transportation, material handling and storage thus requires a much focused attention by managers as it represents a substantial portion of the overall operation costs, with transportation between plants often being the most costly logistics activity (Murphy and Wood, 2004; Ballou, 1987).

Figure 1 (based on Jonsson, 2008, pp. 50) below represents the current state of material flow from Rottne Industri’s first tier suppliers until delivery to dealers. The marked area represents the focus of the thesis.
Figure 1. Material Flow Chart of Rottne Industri current structure
The freight transportation is done by truck between the suppliers and the different manufacturing facilities, as well as for the freight transportation from Stensele and Lenhovda to Rottne. Figure 1 also shows the different reverse flows from the manufacturing plants to the different suppliers, consisting of steel scrap for proper recycling. The distribution of finished goods from Rottne manufacturing plant to the different customers is not made by Rottne Industri but instead through the use of independent shipping companies and third part logistic providers contracted by and at the expense of the customer (Axelsson, Sales Manager Export, 2013).

1.2. Problem discussion

Rottne Industri currently possesses a decentralized production structure but in the long run might consider centralizing all its production activities into its manufacturing plant at Rottne where the final assembly takes place. The driver of this decision is that the material handling, transportation and storage among the different manufacturing plants do not add value to the products manufactured but instead translate into a relatively higher cost when components, spare parts and frames are ordered for final assembly (Axelsson, Sales Manager Export, 2013). Figure 2 (based on Jonsson, 2008, pp. 50) shows the hypothetical situation in which Rottne Industri has chosen a centralized manufacturing structure located in the facility at Rottne resulting in less dispersed material flow (see legend Figure 1).
As previously mentioned decentralized organizational structures often prove to provide greater flexibility, cooperation and sharing of information between the different business units of a same organization (Jonsson, 2008). However in the case of Rottne Industri, the constant logistics activities occurring with the transportation from the steel suppliers and components between the different facilities, the decentralized manufacturing structure is more than likely to create additional costs (Christopher, 2005, 2007).

If Rottne Industri were to switch to a centralized manufacturing structure as shown in Figure 2, freight transportation and its costs is likely to be positively affected. In overall, the assumption is that the movement of goods would decrease in terms of distance and time along the supply chain since the raw materials and components previously delivered at Lenhovda and Stensele are being redirected toward Rottne. However, further research will have to consider the necessary long term investments for centralizing the manufacturing structure, mainly concerning the need and cost for expanding the manufacturing facilities in order to reach the required production capacity and adapt the storage layout for better material handling.

**Figure 2. Material Flow Chart of Rottne Industri centralized structure**

As previously mentioned decentralized organizational structures often prove to provide greater flexibility, cooperation and sharing of information between the different business units of a same organization (Jonsson, 2008). However in the case of Rottne Industri, the constant logistics activities occurring with the transportation from the steel suppliers and components between the different facilities, the decentralized manufacturing structure is more than likely to create additional costs (Christopher, 2005, 2007).

If Rottne Industri were to switch to a centralized manufacturing structure as shown in Figure 2, freight transportation and its costs is likely to be positively affected. In overall, the assumption is that the movement of goods would decrease in terms of distance and time along the supply chain since the raw materials and components previously delivered at Lenhovda and Stensele are being redirected toward Rottne. However, further research will have to consider the necessary long term investments for centralizing the manufacturing structure, mainly concerning the need and cost for expanding the manufacturing facilities in order to reach the required production capacity and adapt the storage layout for better material handling.
Freight transportation is a primary target of interest in order to evaluate the efficiency of the supply chain as its study will allow managers to detect areas of errors and correct them for a better cost effective logistics system (Christopher, 2005). Logistics activities do not add any value to the product, except when it comes to short delivery time for the customer (Jones et al, 1997; Christopher, 2005). Especially in a decentralized production structure, the production of most goods stretches across the entire organization, thus implying a high number of logistics activities between the different manufacturing processes. As mentioned previously, logistics activities represent a substantial portion of the operation costs in general, with freight transportation usually representing the most costly logistics activity (Murphy and Wood, 2004; Ballou, 1987). Therefore the calculations of freight transportation costs from the main suppliers to the facilities, as well as between the different plants, represent a beginning for evaluating the differences in monetary terms between centralized and decentralized structure.

In addition to freight transportation cost, the environmental cost of such activity has to be taken into consideration. Countries evaluate environmental costs along different criteria, such as traffic congestion, release of dangerous substances, noise and so on. The environmental impact is mainly related to transportation and more specifically to road transportation in overall (Enarsson, 2006), especially for Sweden as the environmental impact is calculated in accordance to the amount of hazardous emission in the atmosphere. Although environmental costs are not directly sustained by companies in term of monetary expense, they are still taken into consideration when it comes to assess the total cost for transportation. Therefore, in addition to transportation cost in general, the related environmental costs caused by these activities have to be considered and evaluated in order to gain a more precise estimation of the total transportation cost.
1.3. Research questions

Three Research Questions were identified:

- What is the freight transportation cost from suppliers to all Rottne Industri AB facilities and between them?
- How would this freight transportation cost change if Rottne Industri AB was to centralize all its activities into one facility at Rottne?
- How would the environmental cost related to freight transportation difference be if such a switch occurred?

1.4. Purpose

The purpose of this paper is to identify the freight transportation costs between the steel suppliers and the three manufacturing plants at Stensele, Lenhovda and Rottne as well as those for goods from Stensele and Lenhovda to Rottne. Moreover, the research seeks to analyze the difference in transportation costs if Rottne Industri was to centralize all its activities into one single manufacturing facility at Rottne. Finally, the authors aim to identify the environmental cost related to freight transportation in order to evaluate the total transportation cost difference between the two scenarios.

1.5. Limitation

Even though Rottne Industri purchases from more 400 suppliers (Axelsson, Sales Manager Export, 2013), its main orders are for steel material, which is ordered from 10 suppliers. Other components such as tires, engines and electronic and plastic components are only shipped to Rottne for the latest steps of the assembly. Because they are delivered to the facility at Rottne only, changes from a decentralized to a centralized structure would not affect the related material flow and transportation costs. Therefore it is not relevant for the purpose of this thesis to analyze the related costs. The data collected for this research only refers to the fiscal year 2012.

In the analysis of the transportation costs the authors will not consider the cost of capital tied-up during in-transit transportation. Finally, the reverse flow from Rottne
Industri’s facilities to suppliers will not be considered in the calculations of the total transportation cost.

1.6. Disposition of the thesis

The Master thesis will proceed according to the disposition shown in Figure 3, each of the six forms corresponds to a chapter of the thesis.

Figure 3. Thesis disposition
2. Methodology

The presentation of the different research methods are presented on this chapter, concerning the scientific perspective, approach, the way data are collected and analyzed. Moreover the scientific credibility of the thesis is addressed as well as the ethical considerations related to the research. All subchapters present at first the theoretical frame about the different methodologies before presenting those chosen for this master thesis.

2.1. Scientific perspective

The scientific perspective of business research provides a mapping for researchers to formulate, execute and analyze their business research. These three stages are the prerequisite for a sound decision making process for which theories and hypotheses are designed and data from appropriate sources are collected for a correct assessment of how theories can have actual results in an empirical context (Hair et al, 2003). Two general perspectives are generally considered by researchers: positivism and hermeneutics (Gummesson, 2000).

Positivism is an objective perspective which involves empirical testing an experimentation in order to produce knowledge by proving or disproving the hypothesis and generate new theories and principles by putting facts together and finding patterns (Bryman and Bell, 2003). The researcher must take an objective, detached position towards the study, trying to do the research unbiased (Gummesson, 2000).

The hermeneutic or interpretivist perspective argues that it is impossible to interpret a situation being completely objective. In this case the researcher takes a subjective position and makes his own assumptions in order to understand and interpret the situation for the study (Gummesson, 2000).

Scientific perspective of the thesis

In this thesis, the authors chose the positivistic perspective. First, general theoretical concepts are being presented. The theoretical framework is used to understand and interpret the empirical findings gained from Rottne Industri and presented in this thesis.
Therefore, the theoretical framework is used to support or dismiss the findings in the analysis.

2.2. Scientific approach

The scientific approach concerns the necessary steps or guidelines researchers have to undertake in order to conduct a scientific research (Ethridge, 2004). Several approaches exist when it comes to how researchers perceive the empirical reality and its results. Two general perspectives are the deductive and inductive approach (Gummesson, 2000).

In the deductive approach, the researcher begins by theories and predictions about the expected empirical results. This must then be verified by the actual empirical findings (Hyde, 2000). With the deductive approach the researchers start by using existing theory which later apply to an existing real life situation in order to define it with respect to the theory (Ethridge, 2004).

The inductive approach is the complete opposite of deductive scientific approach. In this situation, researchers start by collecting empirical findings, analyze them and then try to find patterns. General assumptions can be established, usually after several studies which in turn can lead to the creation of new theoretical models and frameworks (Hyde, 2000).

The scientific approach of the thesis

A deductive approach is selected for the thesis as the theoretical concepts presented in the theory chapter are used to define the actual empirical situation of Rottne Industri. Existing theory is being used to better explain and define the empirical data presented in this thesis.

2.3. Research method

The choice of research method depends on the purpose of study whether it is for academic purpose with the aim of adding to previous knowledge, or for practical application in collaboration with practitioners in order to help them for sound decision making (Greener, 2008; Gibbons et al., 1994).
2.3.1. Qualitative and quantitative research

Researchers have to decide on whether base their approach on a qualitative or quantitative research depending on their ultimate goal. Qualitative research represents the “description of things that are made without assigning number directly” (Hair et al., 2003, pp. 74), while a quantitative research involves “measurements in which numbers are used directly to represent the properties of something” (Hair et al., 2003, pp. 74).

According to Greener (2008) and Thompson (2004), a quantitative research method is usually associated with a deductive approach when it comes to theory testing with the use of a positivistic perspective. On the other hand, a qualitative research is more likely to be associated with an inductive approach for theory. However, because business research encompass a wide variety of academic disciplines, business researchers have to consider mixing both qualitative and quantitative research methods (Saunders et al., 2007). The reason for this mix of data collection is because it enables researchers to offer a broader picture of what they are studying and how their theories and analysis will affect organizations as a whole, as well as providing new areas of investigation for further research (Greener, 2008).

2.3.2. Case study

A case study is one of the most widely used approaches for undertaking business research (Tight, 2009). According to Stake (1995, pp. xi), a case study is “the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances“. It usually considers five key requirements: issue choice, triangulation, experiential knowledge, contexts and activities (Stake, 2005). Moreover, three main types of case study can be identified:

- Intrinsic: study undertaken for better understanding of a particular case;
- Instrumental: study conducted to provide insight into an issue and propose solution;
- Multiple or collective: several cases are studied together in order to explore a phenomenon.
A case study is mainly a qualitative method, but it often includes a mix between qualitative and quantitative data for better assessment. Although it is important to bear in mind that every research methods has its advantages and disadvantages, many researchers consider case studies to lack precision (usually quantifiable data), objectivity and scientific rigor (Yin, 2003). On the other hand, a case study allows researchers to conduct an empirical enquiry within a localized boundary of space and time focused on different systems and activities in their natural context. It allows a greater correlation between purely academic intellectual research to actual application for business and policy decision makers via data collection, which enable researchers to explore the different features of a case, create credible interpretation, test the trustworthiness of assumptions and finally construct useful arguments (Bassey, 1999).

2.3.3. Research methods for the thesis

The thesis focuses on an instrumental case study as its purpose is to determine what the costs of transportation for steel material are between Rottne Industri and its suppliers in its current structure and state the difference in a future centralized structure. Qualitative and quantitative research methods will be used for the necessary data collection to bring up a broader picture of Rottne Industri transportation costs and how it will change in a different organizational structure.

2.4. Data collection

Collecting data is an early and very important step in business research. After data are analyzed they support the decision making process, helping to reduce the risk of making costly errors. Research literature generally identifies two main types of data: primary and secondary data (Hair et al., 2003).

2.4.1. Primary and secondary data

Primary data is directly gathered by the researchers so they require more time and resources to be collected (Ethridge, 2004). Depending on the nature and objectives of the study, these data can be gathered by observation, interviews and/or questionnaires (Hair et al., 2003). Observational data can be collected by “systematically recording observation of people, events, or objects” (Hair et al., 2003, pp. 124) and can result in narrative or numerical
data. In a case study, while dealing with complex situations, interviews represent a very useful and effective way to gather information by directly asking questions.

Structured, semi-structured and unstructured interviews represent three sub-categories of this data collection method which are very useful depending on the nature of the phenomena the researchers want to analyze. The way the interview is conducted (face-to-face, telephone or via computer dialogue) may also influence the quality of information collected. Structured interviews represent most rigid type of interview as the interviewer only ask the interviewee a list of predetermined questions. If this method lack of flexibility, it allows to easily compare the answers from different subjects. Semi-structured interviews instead let the researcher free to take the initiative to modify the order of the questions and to formulate new ones in order to enhance the findings. The last type is the depth interview: there is no pre-determined structure in asking questions but it allows exploring the “why” of the studied phenomena (Hair et al., 2003).

Secondary data such as scientific articles, books and all kind of data collected by anyone who is not one of the researchers are available from several different sources which can be normally accessed by libraries. Many statistical, economic and governmental organizations periodically collect data and make them available to the public (Ethridge, 2004).

2.4.2. Thesis data collection

In this thesis information were gathered by direct observation of phenomena occurring in the production plant at Rottne and semi-structured interview to Rottne Industri’s managers. Table 1 below shows the list of interview conducted from the 2013-02-14 to 2013-05-06 in order to collect relevant information:
<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Interviewed</th>
<th>Type of interview</th>
<th>Title of the interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>14/02/2013</td>
<td>Växjö - Linnéuniversitetet</td>
<td>Roland Axelsson (Sales Manager Export)</td>
<td>Face-to-face (Semi-structured)</td>
<td>Interview about Company overview</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>27/02/2013</td>
<td>Rottne – Rottne Industri’s Headquarter</td>
<td>Roland Axelsson (Sales Manager Export)</td>
<td>Face-to-face (Semi-structured)</td>
<td>Interview about Company Internal Processes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/04/2013</td>
<td>Rottne – Rottne Industri’s Headquarter</td>
<td>Roland Axelsson (Sales Manager Export) and Claes-Göran Claeson (Head of Production)</td>
<td>Face-to-face (Semi-structured)</td>
<td>Interview about Company Material Flows</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06/05/2013</td>
<td>Rottne – Rottne Industri’s Headquarter</td>
<td>Roland Axelsson (Sales Manager Export)</td>
<td>Face-to-face (Semi-structured)</td>
<td>Interview about transportation costs</td>
</tr>
</tbody>
</table>

**Table 1. List of interviews**

Secondary data such as scientific articles and books were also analyzed by accessing through the Linnéuniversitetet library to different databases (Emerald, OneSearch, Business Source Premier and Google Scholar) and by direct reading of the paper references. Additional information was gathered through several websites. Moreover quantitative data about Rottne Industri were provided by the company.

### 2.5. Data analysis

The main purpose of analysis is to understand the data previously collected and gain useful insights about the topic. Therefore, there are some analytical procedures that need to be followed so that the data collected can be presented in a structured, orderly manner that will bring meaning to the reader. By using these analytical procedures, the researcher can
dissect, reduce, sort and reconstitute the data. According to Miles and Huberman (1994), three procedures can be data reduction, data display and conclusion drawing and verification.

Data reduction is the first step and involves the selection and transformation of data from different transcripts into a more easily accessible format to enable researchers to identify patterns and generate categories which in turn will lead to explanation on the studied topic. Displaying the data gathered is the next step, in which the information is organized and condensed to allow the authors to draw conclusions and propose further research on the same subject (Ghauri and Grønhaug, 2005).

**Thesis Data analysis**

For the analysis of the collected data, the authors of this research have followed the above sequels of analytical processes and activities. By doing so, the data gathered from the observation of the activities occurred at Rottne’s production plant, and from the semi-structured interviews to the company’s managers, are filtered and narrowed down to what is relevant to the purpose of this research. Through the use of flow charts, the authors will expose the current and supposed material flow occurring in the company in order to highlight the changes in both decentralized and centralized models. The resulting changes in transportation costs for freight transportation will be supported via calculation on distances, weight, costs per tonkilometer (tkm) per type of material, truck related costs and environmental costs. The results of both flow charts and calculation will bring forth conclusions and further recommendation for future studies on the topic of centralization and decentralization of companies’ manufacturing structure and its effects on transportation costs.

The Figure 4 shows how the data collected from Rottne Industri is being used in the analysis to answer all the research questions on transportation and environmental costs.
Figure 4. Model for data analysis
2.6. Scientific credibility

Before the researchers are able to use the empirical information for analysis, they must ensure the data gathered will support the representation of the concept in an accurate and consistent manner. The accuracy of information is associated in the business research environment with the term validity while its consistency with reliability (Hair et al., 2003).

2.6.1. Validity and reliability

Validity is a business research concept defined as “the extent to which a construct measures what it is supposed to measure” (Hair et al., 2003, pp. 174). It involves three kind of validity. The content or face validity refers to the suitability of the items chosen by the researchers to define the construct and it might be assessed by questioning a group of experts. Construct validity involves the understanding and interpretation of the concept measured. Finally criterion validity assesses the correlation between the results and other variables connected (Hair et al., 2003; Greener, 2008).

Reliability is related to the consistency of the findings and assesses the capacity of researchers to replicate the results from application to application (Hair et al., 2003). Therefore the research must be transparent and clear in order to allow the reader to replicate the final results (Saunders et al., 2007).

2.6.2. Scientific credibility of the thesis

The construct validity of this thesis is assured by the use of both primary and secondary data: primary data was collected by interviewing the Sales Manager Export and the Head of Production while many secondary data as literature and company’s statements were analyzed. Moreover the theory chapter of this thesis provides a theoretical overview of the business area analyzed. Finally the supervision of the university tutor, course responsible and the opponent group increased the scientific credibility of the research.

The authors tried to avoid formulating assumption for internal validity of the thesis until it was possible to collect information from primary and secondary sources. Only when these collection did not occurred were the researchers forced to make assumption on the related topic. The External validity is provided by the possibility for other manufacturing
company to apply this research to their company case by paying attention to the possible organizational differences.

The reliability of this thesis is strictly connected by the possibility of interviewing the same people at the company. For the quantitative part, a future researcher may obtain the same findings by analyzing the financial and operative data for the same period directly provided by the company for 2012.

2.7. Ethical considerations

Several ethical issues may occur prior, during and after the research process. Before the actual research project starts, researchers and the studied company have to “translate a decision issue into a researchable proposition” (Hair et al., 2003, pp.105). Researchers also need to honestly and realistically evaluate if their capabilities, resources and skills are sufficient in order to complete the agreed project. Moreover, during and after the research, researchers have the moral obligation to use only the analytical and statistical tools they are sure to have mastered (Hair et al., 2003).

On the other hand the decision maker has to obtain the required knowledge in order to understand and communicate with the researchers and also have realistic expectations on the quality of the project (Hair et al., 2003).

In order to follow the ethical guidelines mentioned above, the authors have had preliminary face-to-face discussion with the Rottne Industri AB’s Export Manager Sales Axelsson, in order to agree on the research topic and limitations. Moreover, the researchers together with Mr. Axelsson agreed about the confidentiality of the information to share and privacy implications.
2.8. **Summary**

<table>
<thead>
<tr>
<th>Scientific perspective</th>
<th>• Positivistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific approach</td>
<td>• Deductive</td>
</tr>
<tr>
<td>Research method</td>
<td>• Instrumental case study</td>
</tr>
<tr>
<td></td>
<td>• Mixed method (qualitative</td>
</tr>
<tr>
<td></td>
<td>and quantitative)</td>
</tr>
<tr>
<td>Data collection</td>
<td>• Primary data (semistructured interview,</td>
</tr>
<tr>
<td></td>
<td>direct observation, official records)</td>
</tr>
<tr>
<td></td>
<td>• Secondary data (articles, books, websites)</td>
</tr>
<tr>
<td>Data analysis</td>
<td>• Model for data analys</td>
</tr>
<tr>
<td>Scientific credibility</td>
<td>• Construct validity</td>
</tr>
<tr>
<td></td>
<td>• Internal and external validity</td>
</tr>
<tr>
<td></td>
<td>• Reliability</td>
</tr>
<tr>
<td>Ethical considerations</td>
<td>• Moral obligation</td>
</tr>
<tr>
<td></td>
<td>• Privacy</td>
</tr>
</tbody>
</table>

**Figure 5. Summary of methodology of the thesis**
3. Theoretical Framework

This chapter highlights the different theories about the main topics of the research: centralization and decentralization, transportation, its costs and the related environmental costs. Those theories, in addition with the following empirical investigation, will serve as a basis for the analytical part of this thesis.

3.1. Centralization and Decentralization

3.1.1. Centralization

After having extended their supply chains internationally, many companies have reached the same conclusion: “effectiveness in global logistics can only be achieved through greater element of centralization” (Christopher, 2005, pp. 222). This conclusion goes into contradiction with the general recognition by managers and researchers that a decentralized structure offer greater flexibility and innovation (Jonsson, 2008) and closer proximity to customer requirements (Kouvelis and Gutierrez, 2001). The centralization of the supply chain means that the different logistics activities such as procurement, transportation, storage and inventory management are handled by a single function located at headquarter (Gadde and Håkansson, 2001).

Even though local decision making is essential for sound business practices, most companies have established some principles for the need to centralize their logistics organization. They base this decision on the fact that the overall control of logistics flows must be centralized to achieve cost optimization (Christopher, 2005) and that advances in planning and control systems in the last decades makes the centralization of logistics flow more efficient and attractive (Meyer et al., 2010). Distribution within and across national boundaries require a central decision-making being established to achieve potential trade-offs. Moreover, centralized distribution and production are likely to result into scales economies in the manufacturing process: if greater volumes are produced on few sites, production costs are lowered down. On the other hand, products might have to travel longer distance, thus translating into higher transportation costs and planning as they take longer to arrive at the manufacturing plant (Christopher, 2005). In addition to increased transport costs, centralization of the supply chain implies several other disadvantages such as longer proximity to customer or different production processes, longer deliver time and no local
existence. On the other hand, centralization is likely to generate economies of scale, reduce the variation in demand upstream in supply chain and reduce non-value adding activities (Jonsson, 2008).

3.1.2. Decentralization

The progress in IT technologies in the last decades have enabled a closer proximity between different business units of a same company no matter their geographic location, thus enabling stronger control over them, resulting in increased attractiveness for decentralization and outsourcing (Schary and Skjøtt-Larsen, 2001). Decentralization means that the different business units or manufacturing facilities are responsible for their own logistics activities, purchases, offers, customer relationship and so on (Gadde and Håkansson, 2001). Logistics decisions are made at a business unit or product level and often affected according to the geographic location they are located in (Murphy and Wood, 2004).

Advocates of decentralization argue that centralized logistics systems are hardly manageable in companies present in different geographic region and stress out that it is preferable to leave the decision and management of distribution function to the different divisions (Murphy and Wood, 2004). The choice of decentralization is mainly due to customer satisfaction in term of delivery time, especially if they require a 24/7 service as a centralized organization is likely not to be responsive enough. Additionally, decentralization of supply chain can reduce transportation costs if suppliers are chosen according to their distance to the manufacturing plant or customer (Kouvelis and Gutierrez, 2001).

3.2. Transportation

Over the past fifty years, transportation has gained a significant role in the management of physical logistics, mainly stressed by changing needs and requirements of inventory management due to ever decreasing product life-cycles, increasing demand for customized products, shorter and shorter delivery time in order to compete with an ever increasing competition due to globalization (Power, 2005). Transportation is therefore considered, in the point of view of physical distribution and material flow, as a mean for integrated supply chain and thus critical for companies’ success as it allows them to compete
via increased speed and flexibility while retaining as low level of inventory as possible (Coyle et al., 2011; Power, 2005).

The transportation of goods as raw materials, components, products and wastes between plants located in different geographical areas is commonly called freight transportation and it excludes the internal transport within a plant. These activities can be carried out in different ways. The most common traffic modes are sea, rail, road and air while pipelines and water carriers are used for special kind of goods. Each of these modes have different characteristics which influence the way the logistical goals are achieved such as speed, costs, environmentally friendly concern and customer service (Jonsson, 2008). When it comes to choose what freight transport to use, managers have to remember a general rule: “the higher the desired reliability, the higher the transport price” (Wiegmans, 2010, pp. 44).

Road transport is frequently used when it comes to higher value good which generate high amount of capital tied-up and is the most commonly used transport mode when it comes to move physical goods inland (Arvis et al., 2010). In Europe, 75% of the freight volume in term of tonkilometers is handled by road transport due to its door-to-door performance in terms of service quality and because of the quality of the road infrastructure in the EU (European Commission, 2003). Road freight transportation is particularly popular for the transportation of small but high value shipments over relatively short distances, in average 350 kilometers to several delivery points (Wiegmans, 2010). Standard trucks usually have a capacity from 10 to 25 tons (Grant et al., 2006).
Table 2 summarizes the economic and service characteristics for road transport (Grant et al., 2006, pp. 207):

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Moderate</td>
</tr>
<tr>
<td>Market coverage</td>
<td>Point-to-point</td>
</tr>
<tr>
<td>Degree of competition</td>
<td>Many</td>
</tr>
<tr>
<td>Predominant traffic</td>
<td>All types</td>
</tr>
<tr>
<td>Average length of haul</td>
<td>350</td>
</tr>
<tr>
<td>(Kilometers)</td>
<td></td>
</tr>
<tr>
<td>Equipment capacity (Tons)</td>
<td>10 to 25</td>
</tr>
<tr>
<td>Speed (Time-in-transit)</td>
<td>Moderate to fast</td>
</tr>
<tr>
<td>Availability</td>
<td>High</td>
</tr>
<tr>
<td>Consistency (deliver time</td>
<td>High</td>
</tr>
<tr>
<td>variability)</td>
<td></td>
</tr>
<tr>
<td>Loss and damage</td>
<td>Low</td>
</tr>
<tr>
<td>Flexibility (adjustment to</td>
<td>High</td>
</tr>
<tr>
<td>shipper’s needs)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Road transportation features (Grant et al., 2006, pp. 207)

Nowadays only few companies carry out the transport activities by themselves. Therefore within the transportation system, other actors play different roles: Logistics Service Providers (LSP) as forwarders, Third-Party Logistics (3PL) and Fourth-Party Logistics (4PL) providers plan and manage the movement of goods while transport operators (i.e. carriers) and infrastructure providers are responsible for maintaining the required infrastructure (Jonsson, 2008).

While forwarders, as mediators of transport services, offer specific services about transportation only, more complex is the role of Third-Party-Logistics service provider. The concept of 3PL was developed in the late 80’s by the American National Council of Logistics Management (CPL), first as “Third-Party Providers” (Yeung Kurn & Chang Wan, 2002). They are organizations to whom companies outsource some or all their logistics activities. They
make use of their own assets and resources in order to manage the logistics function for their client companies (Love, 2004). They provide a multitude of different services in order to add value for their clients’ customers, for example services related to transportation, warehousing, freight forwarding and customs brokerage (Sowinski, 2000). They can lead to more cost-effective solutions for the whole supply chain as they can scale the labor, warehouse and trucking needs facing changes on customers demand and market. Moreover clients expect improvements in lead times, fill rates, inventory, back orders and cost of labor (Richardson, 2002).

However, as important as an efficient distribution system is, problem areas are putting pressure on the different transport and distribution infrastructure, whether a company owns its own fleet of vehicles or outsources the related activities. The physical distribution of goods usually suffers due to fragmented regulatory rules concerning trade laws and government restriction, inadequate intermediaries mainly concerned with the fact that often too many parties are involved in the transportation of one product with an average of 27 per product according to Power (2005) and complication in costs, referring to unforeseen variation in tariffs and taxes between countries (Power, 2005).

3.3. Transportation costs
Transport costs in general, whether it is by air, rail, sea or road, are relatively similar worldwide especially regarding international transport, due to the transport service industry’s organization and regulation (Arvis et al., 2010). Although sea transport is the most commonly used for international deliveries, road is still the most widely used transport mode when it comes to inland transportation, except to those countries where rail road still has a significant traffic share (Arvis et al., 2010).

The key element when it comes to evaluating the different transport costs concerns the vehicle operating costs. Truck operating costs can differ among countries, although the difference is so marginal that it has little significance for international transport. This is usually due to the fact that most transporters have access to the same resources and technology as their competitors, mainly fuel, tires or vehicles. Transport costs in industrial
economies are mainly homogeneous when it comes to long distance tonkilometer value, varying between 0.04 and 0.06 USD (Arvis et al., 2010).

Transport companies usually evaluate their transport costs by breaking down their vehicle operating costs into two categories: fixed costs, referring to the financial charges, depreciation of investment, wages, facilities and taxes which are independent of the vehicle usage frequency; variable costs, focusing on fuel consumption, road user charges, maintenance, tires and taxes proportional to distance or transport trips (Arvis et al., 2010). Therefore, the calculation for operating costs per km is:

\[
\text{Operating Costs per km} = \frac{\alpha}{\lambda \times \text{Dis}} + \frac{\beta}{\lambda}
\]

\(\alpha = \text{Fixed costs of transportation}\)

\(\beta = \text{Variable costs of transportation}\)

\(\text{Dis} = \text{Average distance covered in the period}\)

\(\lambda = \text{Load factor of truck (t)}\)

When transportation activities are not directly undertaken by the company and instead outsourced, it becomes very difficult to lower those costs because they are hidden in the product price. Moreover while goods are in transit it generates capital tied-up which is part of total transportation costs (Jonsson, 2008). According to Daganzo (2005) in order to calculate the total cost per year to transport items from the origin point to the destination one it occurs to sum the costs of all the individual shipments. The cost per shipment can be calculated as followed:

\[
\text{Shipment cost} = c_f + c_v \times V
\]

\(c_f = \text{Fixed cost per shipment}\)

\(c_v = \text{Variable rate depending on the feature of the item transported}\)

\(V = \text{Shipment size}\)
3.4. Environmental costs

A particular category of costs arises during the logistics activities which involves the monetary value of damages to the environment. Transportation has a high negative impact on the environment, mostly due to emissions of dangerous substances into the atmosphere and noise affecting the surrounding areas (Jonsson, 2008). Accidents and the transportation infrastructure are also considered as negative environmental impact. Those environmental costs are difficult to calculate as different countries put different emphasis on what are their primary concerns when it comes to environmental costs (Enarsson, 2006).

Each country has its own weighting factor set on each of the negative environmental effects, depending on what is considered more important. Sweden for example, focuses more upon the hazardous emissions into the atmosphere (Enarsson, 2006). In order to reduce the negative impact and strive for a more environmentally friendly transportation, collaborative efforts of different industries are being made: vehicle manufacturers, oil companies, tyre manufacturers and so on are all taking into consideration the increasing attention of the governments and society towards the environment.

According to Jasch (2003) the overall category of environmental costs involves internal and external costs related to the expenses linked to the damage and protection of the environment. In the case of a company a first sub-category of costs is related to the treatment of emissions and disposal of wastes while a second one refers to the management of preventing environmental damages.

Environmental costs related to transportation are usually considered as one of the primary area for reducing environmental costs. Aronsson and Brodin (2006) suggest an approach strictly related to the companies’ organizational structure in order to lower the effect of logistics activities on the environment and the related costs. Due to increasing environmental concerns on customers end and additional initiative by different governments to reduce externalities produce by industries’ activities, nowadays firms and their stakeholders are becoming more sensitive to the damages caused to the environment, especially about data referring to carbon emissions. The social cost per ton of carbon was
estimated at 28,24 USD in 2012 (Serchuk, 2009). The modern trucks release about 0.036 kg/tkm of carbon (Volvo Truck Corporation, 2003).

Emissions of a road vehicle can depend on vehicle speed, fuel type, the amount of load, vehicle size, the driving pattern and the geographical location of the road. One of the most important cost drivers for road transport is the emission standards of the vehicle, which depend partly on the state and age of the vehicle. Technological developments in vehicles and infrastructure also have an important role, as well as their level of maintenance (Mailbach et al, 2008).

3.5. Flow chart representation
Mapping various business processes like logistics activities or the materials flow, is crucial for every business. Therefore a visual illustration is traditionally used in order to ensure the easier view and understanding for the management and other parties involved. This transformation of business intel in from text to graphic illustration is usually done with the use of flow charts. Flow charts are visual representations that graphically document the various processes and at the same time can be used to illustrate the effects of strategy implementation (Klamm and Weidenmier, 2004).

Flow charts allow different parties to see what their roles are in a process. These charts have the ability to break down a process into individual activities and show the intermingling of actions between departments, business units, manufacturing plants, various actors of a supply chain and so on. Flow charts have helped organization to diagnose, analyze and solve structural problems (Ackoff, 1999). One of the main benefits that flowcharts offer, is that the visual representation of processes allows those who are not familiar with the process to understand how it works as well as possible errors and gaps (Klamm and Weidenmier, 2004).
4. Empirical Investigation

In this section the information and data gathered through documents, interviews and direct observations of the activities at Rottne Industri AB are shown in order to provide the empirical basis for the analysis. It presents a more in depth description of the company, its structure, activities and costs.

4.1. Company description

Rottne Industri is a Swedish manufacturing company founded in 1955. Since then the company has designed and realized a wide range of heavy machinery for the forest industry. The two product categories manufactured are forwarder and harvester which can be customized by adding different pre-designed components and features (Axelsson, Sales Manager Export, 2013). Rottne Industri produces locally in its three Swedish facilities, limiting the outsourcing for only few components, like electrical and plastic components, engines and tires. 45% of the company’s production is exported and sold globally through its dealers located throughout Europe, North America, Russia and Australia (Rottne.com, 2013). The company’s turnover was 450 000 000 SEK in 2012 provided mainly by domestic sales in Sweden, which represents the main market, followed by Canada and Germany (Rottne.com, 2013).

Rottne Industri’s vision aims at producing environmentally friendly machines, better customer support with the final objective of being an industry leader. It focuses on the manufacture of machinery and equipment in the forest industry that are easy to handle and to service, in order to enable the end user to earn money through their utilization (Axelsson, Sales Manager Export, 2013). Adding value for the customer is thus at the heart of the company’s vision and in order to achieve value creation, Rottne Industri bases it strategy mainly focusing on after sales services and repairs warrantee (Axelsson, Sales Manager Export, 2013).

4.2. Organizational structure

The company possesses three manufacturing plants located in Sweden at Rottne, Lenhovda and Stensele. Those three plants are all manufacturing spare parts from raw materials, with the final assembly being made in Rottne Industri’s headquarters at Rottne, where they work on product development. There is also located the service department,
training center and spare parts storage facilities. There are almost 150 people employed in this plant. The 25 employees in Lenhovda manufacture loaders, wagons and tractor frames for different models of forwarders and harvesters while in Stensele, with approximately 50 employees, they manufacture three types of single-grip harvester heads, loader arms and caps for the whole range of machine models (rottne.com, 2013). All components for the final assembly of harvesters and forwarders are being made by Rottne Industri except for some electric components (wires), plastic components, engines and tires. The Figure 6 highlights the internal structure of Rottne Industri and the subsequent flows of material and information, based on the figure presented by Jonsson (2008, pp. 31).
Figure 6. Rottne Industri flow chart as a decentralized manufacturing structure
Information flow

Freight transportation (focus of the thesis)

Distribution

Internal transportation (material handling)

Return of scrap metal

Return of defective spare parts and machinery

The table below, based on Jonsson (2008, pp. 30), describes the activities mentioned in Figure 6 in order to highlight the actions taking place within and how they are related to each other. A more detailed explanation of the whole process will be made after these activities description.

<table>
<thead>
<tr>
<th>Number</th>
<th>Activity description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rottne Industri forecasts the annual demand for its products based on market research and actual customer orders.</td>
</tr>
<tr>
<td>2</td>
<td>Planning the orders for required raw materials and components for the different production steps.</td>
</tr>
<tr>
<td>3</td>
<td>Sending the order to suppliers.</td>
</tr>
<tr>
<td>4</td>
<td>Shipment arrives at the facilities and the staff checks the BOM, the quality of shipment and if the correct volume has been delivered.</td>
</tr>
<tr>
<td>5</td>
<td>Goods are unloaded from the trucks and stored in the different storage facilities.</td>
</tr>
<tr>
<td>6</td>
<td>Production process orders the required resources through the MRP, which inform the staff in charge of inventory management to move the necessary material from stock to production.</td>
</tr>
<tr>
<td>7</td>
<td>Components and frames from the production process are stored in wait for final assembly.</td>
</tr>
<tr>
<td>8</td>
<td>Components and frames are assembled into final products and spare parts for potential repairs.</td>
</tr>
<tr>
<td>9</td>
<td>Finished products and spare parts are stored in wait for shipment to dealers.</td>
</tr>
<tr>
<td>10</td>
<td>Customers’ orders are received at Rottne facility.</td>
</tr>
<tr>
<td>11</td>
<td>Machinery and spare parts are prepared to be shipped to the dealers and customers.</td>
</tr>
<tr>
<td>12</td>
<td>Steel scraps generated by the production process are stored waiting to be shipped back to the steel supplier.</td>
</tr>
</tbody>
</table>

A    Suppliers receive the order from Rottne Industri.
B    Suppliers prepare the order and shipment to Rottne Industri.
C    Dealers and customers receive final products.
D    Dealers and customers send back deficient parts to be repaired or replaced to Rottne facility.
E    Suppliers receive the steel scrap from Rottne to be recycled.
F    Customers send their orders to Rottne Industri.

Table 3. Description of activities expressed in Figure 6
4.2.1. Activity description

Due to the particular industrial sector Rottne Industry is on, namely the manufacturing of machinery for the forest industry, the demand is relatively low. Therefore, Rottne Industri bases its production process on the forecast of market trends to manufacture the right amount of machinery and spare parts (Activity 1) for the coming years (Axelsson, 2013). Based on the annual forecast, the Head production manager issues different planning orders to the three manufacturing plants located at Stensele, Lenhovda and Rottne (Activity 2). Independently, the manufacturing facilities evaluate the amount of raw materials and additional components needed to comply with the orders of the production manager (Activity 3) and then place order to the different suppliers if stocks are insufficient. Suppliers in turn receive the orders (Activity A) and prepare the different deliveries to be executed to the three facilities (Activity B).

Rottne, Stensele and Lenhovda receive the raw material they ordered and make a check-up on it to assess if the current amount has been delivered, if it is the correct type of material they ordered and if any damage was caused during transport (Activity 4). The raw materials are then stored (Activity 5), waiting to be transported to the different production workshops. The production department then sends an order through the MRP system to storage to be delivered the required materials for the manufacturing process to begin (Activity 6). The spare parts, frames and components produced are then stored away in an intermediate storage where they will stay until they are required for the final assembly at Rottne (Activity 7). The scrap metals unused during the production process are stored apart (Activity 12) before being shipped back to suppliers for recycling (Activity E).

Spare parts and components stored at Lenhovda and Stensele (Activity 7) are sent to the manufacturing facility at Rottne (Activity 4), where they are stored again with the components and frames stored there. They are then moved to the final assembly line (Activity 8) and once the process is done, they are stored with the other finished products prior to shipment to customers and dealers (Activity 9). Additional scrap metals and steel waste are stored away (Activity 12) before they are also sent back to steel suppliers for proper recycling (Activity E).
The customer orders (Activity F) are received and checked at Rottne (Activity 10), then prepared via orders preparation being sent to the final storage (Activity 11). Final machines are loaded on truck according to the different orders and are finally shipped to the customers or dealers (Activity C). Upon receiving the machinery, customers and dealers check the different goods for damage during transport and other discrepancies. Additional requirement for spare parts and defective machine replacements are sent back to Rottne Industri (Activity D): these demands will be taken into account in the annual forecast (Activity 1) while the physical goods to be replaced are sent to Rottne (Activity 4) where they will be stored away (Activity 7) before repairs.

4.2.2. Steel procurement

The different orders of raw materials and components that Rottne Industri is not able to produce on its own are delivered to each manufacturing plants according to their production planning, realized by the head of production (Claeson, Head of production, 2013). Since the company manufacture its products from scratch, steel is the prominent raw material ordered, while other orders such as electric components, engines or tires are lesser in volume but nonetheless equally important. Orders are being made along the production process, thus requiring careful planning and management to avoid stock-out and thus delays (Claeson, Head of production, 2013).

The main category of raw materials orders is steel. The company purchases its steel supplies from Swedish steel companies. Steel materials are usually ordered in large quantities, so that better prices are provided for Rottne Industri due to economies of scale (Claeson, head of production, 2013). The steel supplier provides Rottne Industri with a guarantee of quality.

Table 4 shows the ten steel purchased in 2012 and delivered to the facilities of Lenhovda and Rottne specifying the type of steel material (tubes, sheets or castings), the weight in tons and the suppliers’ location: 40% of the steel sheets were sent to Rottne together with 70% of the steel tubes while the rest was sent to Lenhovda (Axelsson, Sales Manager Export, 2013).
<table>
<thead>
<tr>
<th>Supplier</th>
<th>Steel material</th>
<th>Location (Sweden)</th>
<th>Weight (t)</th>
<th>Delivered to Rottne (t)</th>
<th>Delivered to Lenhovda (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tubes</td>
<td>Boxholm</td>
<td>49,27</td>
<td>34,49</td>
<td>14,78</td>
</tr>
<tr>
<td>2</td>
<td>Sheets</td>
<td>Malmö</td>
<td>504,77</td>
<td>201,91</td>
<td>302,86</td>
</tr>
<tr>
<td>3</td>
<td>Tubes</td>
<td>Karlstad</td>
<td>0,45</td>
<td>0,32</td>
<td>0,14</td>
</tr>
<tr>
<td>4</td>
<td>Castings</td>
<td>Vetlanda</td>
<td>1,25</td>
<td>-</td>
<td>1,25</td>
</tr>
<tr>
<td>5</td>
<td>Castings</td>
<td>Eksjö</td>
<td>0,07</td>
<td>-</td>
<td>0,07</td>
</tr>
<tr>
<td>6</td>
<td>Sheets</td>
<td>Växjö</td>
<td>159,46</td>
<td>63,78</td>
<td>95,67</td>
</tr>
<tr>
<td>7</td>
<td>Sheets</td>
<td>Jönköping</td>
<td>130,96</td>
<td>52,38</td>
<td>78,58</td>
</tr>
<tr>
<td>8</td>
<td>Tubes</td>
<td>Halmstad</td>
<td>14,39</td>
<td>10,08</td>
<td>4,32</td>
</tr>
<tr>
<td>9</td>
<td>Tubes</td>
<td>Göteborg</td>
<td>4,06</td>
<td>2,84</td>
<td>1,22</td>
</tr>
<tr>
<td>10</td>
<td>Sheets</td>
<td>Malmö</td>
<td>50,78</td>
<td>20,31</td>
<td>30,47</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>915,46</strong></td>
<td><strong>386,11</strong></td>
<td><strong>529,35</strong></td>
</tr>
</tbody>
</table>

Table 4. Steel supplies to Rottne and Lenhovda: type, weight and suppliers’ location

4.3. Transportation

Rottne Industri needs to transport the raw materials and components from the suppliers’ selling points or directly from their production facilities to each of its three manufacturing plants of Lenhovda, Stensele and Rottne. The transport details are usually organized by Rottne Industri by using 3PLs which arrange the transportation by truck.

When it comes to move the components or the spare parts produced in Stensele and Lenhovda to Rottne, where the components are assembled and the spare parts stored, the company can use different transport actors depending on the urgency of having the material for the final assembly steps or to fulfill an order (Axelsson, Sales Manager Export, 2013).

Deliveries from Stensele to Rottne can be entrusted to a 3PL, a delivery courier or to the truck that every Friday leaves Stensele in order to reach Rottne on Monday morning. The distance Stensele – Rottne is 1300 km (Axelsson, Sales Manager Export, 2013). Regarding the freight Lenhovda – Rottne instead, the company generally uses its own truck that delivers twice per week. The distance Lenhovda – Rottne is only 35 km (Axelsson, Sales Manager Export, 2013).
4.4. Transportation costs

The Table 5 below shows the data provided by the company about the transportation costs for different materials such as steel sheets, tubes, castings, components. The data refers to 2012 and involves also the weight of the delivery per product. The Swedish state provides subsidies for transportation depending on the location of the facilities. There is therefore a 30% state subsidies of the gross cost for transportation from suppliers to Stensele and 35% of subsidies for transportation from the facility in Stensele to the one in Rottne (Axelsson, Sales Manager Export, 2013).

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (t)</th>
<th>Transport Cost (SEK)</th>
<th>Transport cost after 30% subsidies (SEK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel sheet</td>
<td>252</td>
<td>382 381</td>
<td>267 667</td>
</tr>
<tr>
<td>Components</td>
<td>387</td>
<td>570 689</td>
<td>399 482</td>
</tr>
<tr>
<td>Castings</td>
<td>43</td>
<td>108 988</td>
<td>76 292</td>
</tr>
<tr>
<td>Steel tube</td>
<td>45</td>
<td>116 286</td>
<td>81 400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>727</strong></td>
<td><strong>1 178 344</strong></td>
<td><strong>824 841</strong></td>
</tr>
</tbody>
</table>

**Table 5. Transport costs from suppliers to Stensele before and after subsidies**

Table 6 provides the same type of information as Table 5 above but refers to the transportation costs from Stensele to Rottne facility.

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (t)</th>
<th>Total Transport Cost (SEK)</th>
<th>Transport cost after 35% subsidies (SEK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine components</td>
<td>1 649</td>
<td>1 437 481</td>
<td>934 363</td>
</tr>
<tr>
<td>Complete machine model</td>
<td>90</td>
<td>139 443</td>
<td>90 638</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1 739</strong></td>
<td><strong>1 576 924</strong></td>
<td><strong>1 025 001</strong></td>
</tr>
</tbody>
</table>

**Table 6. Transport costs from Stensele to Rottne before and after subsidies**

In the Table 6 above is shown that a particular model of machinery was moved from Stensele to Rottne. This was the only model that was not assembled at Rottne but at Stensele, although it was finally stored at the Rottne facility. In June 2012, the company decommissioned the machine (Axelsson, Sales Manager Export, 2013).

Concerning the operating costs for the only truck owned by Rottne Industri used for moving goods between the facilities of Lenhovda and Rottne, the company provided the information concerning fuel consumption, costs for maintenance, driver and taxes. The 12 tons EURO 5 truck was purchased in 1999 and the depreciation estimated by the company
for 2012 amounts to zero. The company estimated a yearly consumption for its truck being about 20 980 liters of diesel. According to the market price for diesel purchased in industrial quantities, the cost per liter of diesel amounted to 12,5 SEK/liter in 2012. The maintenance costs estimated by Rottne Industri for the year 2012 amounts to 58 472 SEK while the company paid 11 520 SEK in taxes related to the truck ownership. The truck is driven part time by an employee who has also other not related tasks in the factory. So the cost for the employee, related to the task of driving the truck only, is estimated being 78 720 SEK per year, taxes included (Axelsson, Sales Manager Export, 2013).

4.5. Summary

The Table 7 below summarizes the data collected about transportation for Rottne Industri:

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Steel supplies to Rottne and Lenhovda: type, weight and suppliers’ location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 5</td>
<td>Transport costs from suppliers to Stensele before and after subsidies</td>
</tr>
<tr>
<td>Table 6</td>
<td>Transport costs from Stensele to Rottne before and after subsidies</td>
</tr>
<tr>
<td>In text</td>
<td>Truck related costs: maintenance, fuel consumption, driver wage, taxes and depreciation.</td>
</tr>
</tbody>
</table>

Table 7. Summary of empirical data gathered
5. Analysis

In this chapter, the authors aim to answer the three research questions stated in the introduction. The first subchapter, related to the first research question, describes how freight transport costs are calculated in light of the current decentralized organization structure of Rottne Industri. The second subchapter refers to the freight transport cost differences in case of switching to a centralized manufacturing structure in order to answer the second research question. The third subchapter deals with the environmental costs related to previously considered transportation activities. The fourth subchapter summarizes the findings for the three research questions and the fifth deals with sensitivity analysis. The authors combine the theory presented in chapter 3 with the empirical data gathered in chapter 4 to support the results found.

5.1. Freight transportation cost in decentralized structure

What is the freight transportation cost from suppliers to all Rottne Industri AB facilities and between them?

5.1.1. Preamble to cost analysis

In order to develop the cost analysis, the actual manufacturing structure of Rottne Industri has to be considered. Figure 6 highlights the different flows and activities taking place between the company’s suppliers and customers, as well as within and between its production facilities. For the purpose of this research, as mentioned in the limitation part, only the inbound flow of material from suppliers to the manufacturing plants of Rottne, Lenhovda and Stensele are taken into account, as well as the freight transportation between Stensele and Lenhovda to Rottne. The reverse flow of materials and distribution system are not taken into account for the current purpose of this thesis, but might be relevant for further studies. Although the reverse flow of material is an important part of logistics activities, the reverse flow of steel material not used during the production process is not addressed in this paper due to lack of relevant information for proper cost estimation. However, even though the reverse flow is not assessed, it is important to notify that since Rottne Industri possesses three manufacturing plants, steel wastage is created at these three sites and therefore needs transportation capacities to be shipped back. Since Rottne Industri owns only one truck for moving goods between the plants, the transportation of scrap metals is taken care of by 3PLs, thus adding additional transport costs.
In this case study, the only traffic mode taken into consideration is the road transport as all suppliers are located in Sweden, meaning only inland transportation is required (Arvis et al., 2010). According to Power (2005) and Daganzo (2005), transportation costs have to be divided into fixed and variable costs taking into consideration carrier characteristics and different operating costs. Since most transportation activities are not made by Rottne Industri, the two cost components are hidden in the final transport price, including all additional services, charged by the 3PL provider (Sowinski, 2000). In the following analysis, the authors have taken into consideration the total transport cost related to the financial data for 2012, as well as Swedish government regulation when it comes to transportation subsidies.

5.1.2. Cost analysis

In order to calculate the transportation costs from suppliers to all Rottne Industri’s facilities and between them, several steps have to be undertaken. The steps are listed below, from 1 to 6, presenting the different calculations made and the tables highlighting the different results.

**Step 1: Calculating the average transport cost per ton from suppliers to Stensele**

First of all, it is necessary to determine the standard cost for transportation (Step 1) from all suppliers to all Rottne Industri’s facilities for all kind of steel supplies (sheets, tubes, castings and components). The formula used to determine this average transport cost per ton is (see Table 8):

\[
\text{Step 1: } \frac{\text{Transport cost (SEK)}}{\text{Weight (t)}}
\]
Table 8. Average transport cost per ton from suppliers to Stensele

**Step 2**: Calculating the average distance per ton from suppliers to facilities for each material type

The second step (Step 2), shown in Table 10, concerns the estimation of the weighted average distance from suppliers to each manufacturing facilities for every different material. The weighted average distance is used in order to assess the estimate distance between the suppliers and the three manufacturing plants according to the orders made in 2012 by Lenhovda and Rottne (see Table 4). The distances from every supplier to every facility were calculated by using the software provided by viamichelin.com (see Table 9). In order to calculate the weighted average distance, the weight of supplies was taken into account according to the distance travelled. The formula used is:

\[
\text{Step 2: } \frac{\sum_{m} (\text{Weight (t)}_m \times \text{Distance to facility (km)})}{\text{Weight (t)}}
\]

\(m\) indicates the different kind of material.

Table 9. Suppliers distance to Rottne Industri’s facilities
### Step 2

<table>
<thead>
<tr>
<th>Suppliers to</th>
<th>Stenele</th>
<th>Lenhovda</th>
<th>Rottne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Av.ge dist. per ton of tubes (Km)</td>
<td>1 085</td>
<td>234</td>
<td>265</td>
</tr>
<tr>
<td>Av.ge dist. per ton of sheets (Km)</td>
<td>1 316</td>
<td>168</td>
<td>182</td>
</tr>
<tr>
<td>Av.ge dist. per ton of castings (Km)</td>
<td>1 122</td>
<td>69</td>
<td>83</td>
</tr>
<tr>
<td>Av.ge dist. per ton of components (Km)</td>
<td>1 174</td>
<td>157</td>
<td>177</td>
</tr>
</tbody>
</table>

Table 10. Weighted average distance per ton from suppliers to facilities for each material type

### Step 3: Calculating the average transport cost per tonkilometer from suppliers to Stenele

After determining the average transport cost per ton and the weighted average distance between suppliers and facilities, the next action deals with determining the average transport cost per tonkilometer (Step 3). As the transport cost for each type of material was provided by Rottne Industri for transport from suppliers to Stenele, the authors were able to combine the average transport cost per ton found in Step 1 and the average distance per ton to each facility in Step 2 in order to find the average transport cost per tonkilometer for every material type. The authors assume that moving different types of steel material has the same cost per tkm depending on what kind of good is shipped (steel sheet, castings or steel tubes). It is also assumed that the distance for components can be calculated as an average distance between all suppliers and the facilities. The average transportation cost per tonkilometer from suppliers to Stenele is the basis for further estimates. The formula for determining this step equals:

\[
\text{Step 3: } \frac{\text{Average transport cost per } t_m}{\text{Average distance per } t_m}
\]

<table>
<thead>
<tr>
<th>Suppliers to Stenele</th>
<th>Step 1</th>
<th>Step 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Material</strong></td>
<td><strong>Weight (t)</strong></td>
<td><strong>Transport Cost (SEK)</strong></td>
</tr>
<tr>
<td>Steel sheet</td>
<td>252</td>
<td>382 381</td>
</tr>
<tr>
<td>Components</td>
<td>387</td>
<td>570 689</td>
</tr>
<tr>
<td>Castings</td>
<td>43</td>
<td>108 988</td>
</tr>
<tr>
<td>Steel tube</td>
<td>45</td>
<td>116 286</td>
</tr>
</tbody>
</table>

Table 11. Average transport cost per tonkilometer from suppliers to Stenele
Step 4: Calculating the transportation costs from suppliers to Lenhovda and Rottne

Based on the calculation carried out for Step 2 and 3, the transportation cost from suppliers to the facilities of Lenhovda and Rottne can be performed (Step 4) in Table 12 and 13. The transport cost is found by the following formula:

\[ \text{Step 4: Weight} \ (t)_m \times \text{Av. ge transport distance} \ (Km)_m \times \text{Av. ge transport cost per tkm} \ (SEK)_m \]

### Suppliers to Lenhovda

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (t)</th>
<th>Av.ge Transport distance (Km)</th>
<th>Av.ge transport cost per tkm (SEK)</th>
<th>Transp. Cost (SEK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel sheets</td>
<td>508</td>
<td>168</td>
<td>1,15</td>
<td>98 404</td>
</tr>
<tr>
<td>Steel tubes</td>
<td>20</td>
<td>265</td>
<td>2,38</td>
<td>11 146</td>
</tr>
<tr>
<td>Castings</td>
<td>1</td>
<td>69</td>
<td>2,26</td>
<td>156</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>109 706</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12. Transportation cost from suppliers to Lenhovda

### Suppliers to Rottne

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (t)</th>
<th>Av.ge Transport distance (Km)</th>
<th>Av.ge transport cost per tkm (SEK)</th>
<th>Transp. cost (SEK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel sheets</td>
<td>338</td>
<td>182</td>
<td>1,15</td>
<td>70 930</td>
</tr>
<tr>
<td>Steel tubes</td>
<td>48</td>
<td>265</td>
<td>2,38</td>
<td>30 295</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>101 225</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 13. Transportation cost from suppliers to Rottne

Step 5: Calculating the transportation costs from Lenhovda to Rottne

According to Daganzo (2005) and Arvis et al. (2008), to calculate the transportation costs requires the identification of both fixed and variable cost components.

From the empirical data collected, the company estimated a yearly fuel consumption for its truck used to move material from Lenhovda to Rottne of about 20 980 liters of diesel. It means the total cost for fuel consumption in 2012 is the result of the liters of fuel consumed per cost per liter equal to 12,5 SEK/liter and it amounts to 262 250 SEK. In Table
14 (Step 5) is shown the transportation cost from Lenhovda to Rottne as the result of several cost elements related to Rottne Industri’s own truck and related to its ownership and its usage.

In this case some of the cost elements like fuel consumption, maintenance and driver salary can be considered as variable costs as they depend by the usage of the truck done. On the other hand, depreciation and taxes are unrelated to the km run by the truck and are regulated by fiscal law.

<table>
<thead>
<tr>
<th>Lenhovda to Rottne</th>
<th>Step 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost elements</td>
<td>Tot. Cost (SEK)</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>262 250</td>
</tr>
<tr>
<td>Maintenance</td>
<td>58 472</td>
</tr>
<tr>
<td>Driver’s salary (Including taxes)</td>
<td>78 720</td>
</tr>
<tr>
<td>Depreciation</td>
<td>0</td>
</tr>
<tr>
<td>Taxes</td>
<td>11 520</td>
</tr>
<tr>
<td>Total</td>
<td>410 962</td>
</tr>
</tbody>
</table>

**Table 14. Transportation cost from Lenhovda to Rottne**

**Step 6: Freight transportation cost for the decentralized structure of Rottne Industri**

It is now possible to summarize the results (Step 6) obtained in the previous steps and the one directly provided by Rottne Industri, mainly concerning the transportation cost from suppliers to Stensele and Stensele to Rottne exposed in the empirical investigation, in order to calculate the estimated freight transportation costs in the decentralized organizational structure of Rottne Industri AB for the year 2012, as expressed in Table 15.

<table>
<thead>
<tr>
<th>Transport cost (2012)</th>
<th>Decentralized (Step 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers to</td>
<td>Rottne 101 225</td>
</tr>
<tr>
<td></td>
<td>Lenhovda 109 706</td>
</tr>
<tr>
<td></td>
<td>Stensele 824 841</td>
</tr>
<tr>
<td>Freight transportation from</td>
<td>Stensele 1 025 001</td>
</tr>
<tr>
<td></td>
<td>Lenhovda 410 962</td>
</tr>
<tr>
<td></td>
<td>Lenhovda 2 471 735</td>
</tr>
</tbody>
</table>

**Table 15. Freight transportation cost for the decentralized structure of Rottne Industri**
5.1.3. Findings discussion

According to Gadde and Håkansson (2001), a company with a decentralized organizational structure uses its different facilities as business units, enabling them to perform their own purchases, logistics activities, offers and so on. Logistics decisions are also made at a local level for greater flexibility and customer relationship as supported by Murphy and Wood (2004). Furthermore, transportation costs are expected to be lower than those of a centralized organization as suppliers are selected primarily on a local level to suit the business units’ needs (Kouvelis and Gutierrez, 2001).

However, the findings about transportation costs from suppliers to Stensele dismiss the theories expressed by the previous authors. It can be mostly explained by the organizational structure of Rottne Industri: the different manufacturing facilities are not business units carrying out their own agendas as they are taking their orders from Rottne’s facility according to its annual forecast (see Figure 6). Even though most suppliers are located in a convenient distance from Lenhovda and Rottne, the fact that Stensele is located so far from the two other factories and economic center for Sweden implies higher transportation cost in overall, even with subsidies from the Swedish government.

Moreover, the average transport cost per tkm for each different material (as shown in Step 3 in Table 11) results much higher than the estimated worldwide average transport cost for long distances which, according to Arvis et al. (2010) vary between 0,04 USD (0,27 SEK) and 0,06 USD (0,4 SEK).

5.2. Freight transportation cost difference between centralized and decentralized structure

How would this freight transportation cost change if Rottne Industri AB was to centralize all its activities into one facility at Rottne?

5.2.1. Centralized organizational structure

In order to determine the cost difference between a centralized and decentralized manufacturing structure for Rottne Industri, it is important to expose first what is likely to change in its organizational structure, mainly concerning the flow of material and its transportation. Based on the model presented in Figure 6 describing the activities and flows
involved in the current decentralized structure of Rottne Industri, Figure 7 was created to highlight the differences in those activities and flows in case of centralization at the facility in Rottne (see legend Figure 6).
Figure 7. Rottne Industri flow chart as a centralized manufacturing structure
As shown in the Figure 7, both the manufacturing facilities of Lenhovda and Stensele do not exist anymore, hence the previous inbound transportation from suppliers to those facilities are redirected to the one in Rottne. Most of the activities taking place in the new model are the same occurring in the decentralized manufacturing structure of Rottne Industri (see Figure 6). According to Christopher (2005), centralization in manufacturing structure is likely to enable economies of scales in production, while at the same time make the whole structure easier to manage. Figure 7 shows that managing the supply chain is likely to be easier since freight transportation from Stensele and Lenhovda to Rottne are not needed anymore, as well as the necessary planning and following of those activities to ensure a continuous flow of material according to production needs and maintaining as low level of inventory as possible (Power, 2005; Coyle et al., 2001).

Rottne Industri still focuses on annual forecast to determine the number of machineries to build, establish the planning order consequently and send orders to suppliers. In turn, they supply the facility in Rottne according to the order received, with the proper check-up being made at delivery before storage and production process. The internal transportation in the centralized structure is the same as in the decentralized one however with higher volumes due to the concentration of all manufacturing processes into one production plant.

Because all components and frames are being made at Rottne where the final assembly line is at, the need to transport components and frame from other facilities to Rottne is not required anymore, thus reducing the complexity of procurement between the different facilities as in the decentralized structure (Power, 2005; Coyle et al., 2011). Once the machinery and spare parts are produced, they are stored waiting for customer orders. The same process as in the decentralized structure takes then place, with Rottne Industri delivering final products to dealers and customers and receiving back defective spare parts or machinery, whose orders will be added to the annual forecast. Moreover, steel scraps generated during the production process and final assembly are also sent back to the suppliers for proper recycling.
5.2.2. Transportation cost in centralized structure

In order to calculate the cost in the centralized structure the authors determine the freight transportation cost that will take place. In order to enable a future comparison, the only transportation cost incurring in the new centralized structure are the one for the procurement of goods from suppliers to the only remaining facility at Rottne. The freight transport cost per different type of material is found by the following formula:

\[ \sum[Total\ Weight\ (t)_m \times Av.ge\ transp.\ dist.\ (Km)_m \times Av.ge\ transp.\ cost\ per\ tkm\ (SEK)_m] \]

<table>
<thead>
<tr>
<th>Suppliers to Rottne</th>
<th>Weight (t)</th>
<th>Av.ge transp. dist. (Km)</th>
<th>Av.ge transp. cost per tkm (SEK)</th>
<th>Freight Transp. Cost (SEK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>R</td>
<td>L</td>
<td>S</td>
<td>Tot.</td>
</tr>
<tr>
<td>Sheets</td>
<td>338</td>
<td>508</td>
<td>252</td>
<td>1098</td>
</tr>
<tr>
<td>Tubes</td>
<td>48</td>
<td>205</td>
<td>45</td>
<td>113</td>
</tr>
<tr>
<td>Castings</td>
<td>1</td>
<td>43</td>
<td>44</td>
<td>83</td>
</tr>
<tr>
<td>Components</td>
<td>387</td>
<td>529</td>
<td>726</td>
<td>1642</td>
</tr>
<tr>
<td></td>
<td>386</td>
<td>529</td>
<td>726</td>
<td>1642</td>
</tr>
</tbody>
</table>

Table 16. Freight transport cost for the centralized structure

5.2.3. Cost difference

Table 17 below summarizes the results found about the freight transportation cost in both centralized and decentralized structure.

<table>
<thead>
<tr>
<th>Transport cost (2012)</th>
<th>Decentralized</th>
<th>Centralized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers to</td>
<td>Rottne</td>
<td>101 225</td>
</tr>
<tr>
<td></td>
<td>Lenhovda</td>
<td>109 706</td>
</tr>
<tr>
<td></td>
<td>Stensele</td>
<td>824 841</td>
</tr>
<tr>
<td>Freight transportation from</td>
<td>Stensele</td>
<td>1 025 001</td>
</tr>
<tr>
<td></td>
<td>Lenhovda</td>
<td>410 962</td>
</tr>
<tr>
<td>Total</td>
<td>2 471 735</td>
<td></td>
</tr>
</tbody>
</table>

Table 17. Freight transport costs difference between centralized and decentralized manufacturing structure

According to the results found in Table 17, summarizing the calculations for transportation costs made for both manufacturing structures, it is clear that the centralized structured would infer less transportation costs than the current decentralized one.
According to the calculation and assumptions of the authors, a centralized structure would result in a drop in transport costs by approximately 84% (2 075 440 SEK).

5.2.4. Additional costs implications

The costs savings resulting from the calculations in the previous chapter have to be assessed from a wider perspective in order to lead Rottne Industri’s management to undertake important strategic decisions about the possible new organizational structure.

The savings margin of 2 075 440 SEK per year (calculated on the basis of 2012) has to cover many additional costs related to the long term investments necessary for increasing the production capacity at Rottne’s facility. The new capacity will have to be quantified depending by the forecast about the future market demand.

At first investments related to the new facility layout have to be considered: the manufacturing process currently operating at Stensele and Lenhovda facilities has to be re-engineered at Rottne’s. The machineries currently running at the dismissed facilities will be moved to the one in Rottne and the manpower relocated.

However the company will gain some operational advantages due to the elimination of part of its current material handling activities and the opportunity of consolidate the inbound deliveries of raw materials. Moreover some of the high and medium level management positions can be centralized. This will lead to additional cost savings not considered in the previous savings margin.

Finally, even though the company will suffer economically because of the high amount of investments necessary for making viable the new centralized structure, Rottne Industri will obtain many advantages in the long run, after the investments will be totally written off.

5.3. Environmental cost in decentralized and centralized structure

*How would the environmental cost related to freight transportation difference be if such a switch occurred?*
In addition to the transportation costs calculated in both the decentralized and centralized structure, the transport activities involve additional costs related to the damage caused by carbon emission to the environment. Sweden is particularly sensitive to this topic and puts emphasis on hazardous emission as their primarily concerns when it comes to evaluate environmental costs (Enarsson, 2006). In order to calculate this cost category, the authors consider the social cost (cost sustained by society but not directly paid by the company) which is estimated at 28,24 USD (188,71 SEK) per ton of CO2 emitted (Serchuk, 2009), quantified as 0,036 kg per tkm according to Volvo Truck Corporation (2003).

Calculating the amount of CO2 emission in kg per tkm was made using the following formula:

$$ Weight \ (t) \times Trans.\ Dist.\ (km) \times 0,036 $$

The result of the calculation can then be used to calculate the overall environmental cost caused by the transportation activities from suppliers to Rottne Industri manufacturing facilities on both decentralized and centralized structure using the following formula:

$$ \frac{CO2\ emission\ in\ kg\ per\ tkm}{1000} \times standard\ cost\ per\ ton\ of\ CO2 $$
Environmental Cost | Weight (t) | Trans. Dist. (km) | CO2 emission in kg per tkm | Total Env. cost per t on of CO2
--- | --- | --- | --- | ---
Decentralized | Suppliers to Stensele | 726 | 1 174 | 30 694 | 5 792
| Suppliers to Lehovda | 529 | 157 | 2 994 | 565
| Suppliers to Rottne | 386 | 177 | 2 455 | 463
| Stensele to Rottne | 1 739 | 1 300 | 81 367 | 15 355
| Lenhovda to Rottne | 900 | 35 | 1 134 | 214
| Total | | | | **22 390**
Centralized | Suppliers to Rottne | 1 642 | 177 | 10 440 | **1 970**

**Table 18. Carbon emissions and environmental cost**

It is possible to notice that in the centralized structure, the environmental cost would be reduced by approximately 91% (20 420SEK) due to the shorter transport distance.

### 5.4. Summary of the analysis

Following the comparison in environmental costs between centralized and decentralized structure of Rottne Industri in Table 18, the table below summarizes the findings about total transportation costs in both manufacturing structures.

<table>
<thead>
<tr>
<th>Transport cost (2012)</th>
<th>Decentralized</th>
<th>Centralized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rottne</td>
<td>101 225</td>
<td>396 295</td>
</tr>
<tr>
<td>Lehovda</td>
<td>109 706</td>
<td></td>
</tr>
<tr>
<td>Stensele</td>
<td>824 841</td>
<td></td>
</tr>
<tr>
<td>Freight transportation from</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stensele</td>
<td>1 025 001</td>
<td></td>
</tr>
<tr>
<td>Lenhovda</td>
<td>410 962</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2 471 735</td>
<td>396 295</td>
</tr>
<tr>
<td>Environmental cost</td>
<td>22 390</td>
<td>1 970</td>
</tr>
<tr>
<td><strong>Total transportation costs</strong></td>
<td><strong>2 494 125</strong></td>
<td><strong>398 265</strong></td>
</tr>
</tbody>
</table>

**Table 19. Total transport costs difference between centralized and decentralized manufacturing structure**

According to the results found in Table 19 which summarizes the calculation for transportation cost in the decentralized structure, the centralized as well as the environmental costs related to transportation in both structures, it is clear that the total transportation cost will be lower in case of centralization while the environmental impact would be reduced. The results above show that the total transport cost would drop by
approximately 84% (2 095 860 SEK). The Table 20 below summarizes the reduction in transportation, environmental and total transportation costs occurring by switching from the decentralized to the centralized manufacturing structure.

<table>
<thead>
<tr>
<th>Centralized Structure</th>
<th>Cost reduction (SEK)</th>
<th>Cost reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport cost</td>
<td>2 075 440</td>
<td>84</td>
</tr>
<tr>
<td>Environmental cost</td>
<td>20 420</td>
<td>91</td>
</tr>
<tr>
<td>Total transportation</td>
<td>2 095 860</td>
<td>84</td>
</tr>
</tbody>
</table>

Table 20. Cost reduction in centralized structure

5.5. Sensitivity analysis

The analysis below aims to show the relations between transportation costs and the entity of subsidies provided by the Swedish government. The authors present in Table 21 three different scenarios: in the first it is assumed that no subsidies are provided to Rottne Industri for any of its transportation route; the second one is the case analyzed in the previous chapter 5.1. where the Swedish administration gives back to the company 30% of the transportation costs incurred in the material flow between its suppliers and the facility in Stensele and 35% of those incurred between the latter and the one at Rottne; the last case involves the increase amount of subsidies from 30 to 45% and from 35 to 50%. Moreover, as the environmental costs would not be affected by changes in state subsidies, they are not considered in the following calculations.
The results show a decrease in transportation costs in the decentralized structure in the opposite direction of the amount of subsidies provided. It is possible to notice how, in case of the interruption for the state subsidies provided by the government, Rottne Industri would face an increase of its transportation costs by about 50%.

The Figure 8 below provides a visual representation of the previous results.

**Table 21. Transportation costs sensitivity to subsidies**

<table>
<thead>
<tr>
<th>Suppliers to</th>
<th>Decentralized</th>
<th>Centralized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No subsidies</td>
<td>%</td>
</tr>
<tr>
<td>R</td>
<td>101 225</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>109 706</td>
<td>3</td>
</tr>
<tr>
<td>S</td>
<td>1 178 344</td>
<td>35</td>
</tr>
<tr>
<td>Freight transp. from</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>1 576 924</td>
<td>47</td>
</tr>
<tr>
<td>L</td>
<td>410 962</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>3 377 161</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>396 295</td>
</tr>
</tbody>
</table>

**Figure 8. Transportation cost sensitivity to subsidies**

Additional sensitivity analysis can be done using different factors such as the distance from suppliers to the facilities or the operating costs of the truck owned by Rottne Industri.
Such analysis were not made in this paper as more detailed information are required to effectively perform such a task, information that the authors did not possess. If suppliers’ locations were to be moved, the distances between them and the facilities would obviously change, but to what extent, it is not known as it would not be a linear process to estimate the new distances.
6. Conclusion

A final discussion is developed in this chapter to remind the findings and highlight some of the discrepancies discovered. In addition several propositions are being made in order to provide new study areas and different perspectives for further researches.

6.1. Final discussion

Through this paper, the authors aimed at calculating the actual freight transportation cost incurring from Rottne Industri’s suppliers to its different facilities and those occurring between these facilities. Moreover, the intent was to calculate the difference in transportation costs in a scenario in which Rottne Industri had centralized all its manufacturing activities into one facility. Thereafter, the authors focused on the environmental cost that the previous transportation activity were generating in order to assess the difference between the decentralized and centralized scenarios. The analysis was based on data directly obtained from the company as well as assumptions on the part of the authors as to what activities and flows might change in the new structure as well as how the costs for different components was calculated according to distance. The analysis was carried on following the three research questions.

6.1.1. What is the freight transportation cost from suppliers to all Rottne Industri AB facilities and between them?

The first research question focused on the current decentralized structure of Rottne Industri. The findings highlight the high weight represented by freight transportation cost from suppliers to the facility in Stensele and from the latter to the one in Rottne. The results of the different calculation are show in Table 22.

<table>
<thead>
<tr>
<th>Transport cost (2012)</th>
<th>Decentralized structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers to</td>
<td></td>
</tr>
<tr>
<td>Rottne</td>
<td>101 225</td>
</tr>
<tr>
<td>Lenhovda</td>
<td>109 706</td>
</tr>
<tr>
<td>Stensele</td>
<td>824 841</td>
</tr>
<tr>
<td>Freight transportation from</td>
<td></td>
</tr>
<tr>
<td>Stensele</td>
<td>1 025 001</td>
</tr>
<tr>
<td>Lenhovda</td>
<td>410 962</td>
</tr>
<tr>
<td></td>
<td>2 471 735</td>
</tr>
</tbody>
</table>

Table 22. Freight transportation cost in the decentralized structure
6.1.2. How would this freight transportation cost change if Rottne Industri AB was to centralize all its activities into one facility at Rottne?

At first, in order to understand the research question, the authors had to figure out what the new centralized structure would look like. In order to do so, the new structure and the related activities were presented through a flow chart to allow clear comparison between the centralized and decentralized structure (see Figure 6 and 7). The resulting activities are more simplified in the centralized structure because of the removal of both manufacturing plants in Stensele and Lenhovda, translating in cost saving in transportation in overall since the transportation activities between the three plants cease to be. The Table 23 below shows the transport cost difference in case of centralizing the activities in one plant. Although the freight transportation cost to Rottne will increase by 291%, the total freight transportation will decrease by 84% (2 075 440 SEK) compared to the freight transportation cost in the decentralized structure.

<table>
<thead>
<tr>
<th>Transport cost (2012)</th>
<th>Decentralized</th>
<th>Centralized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suppliers to Rottne</td>
<td>101 225</td>
<td>396 295</td>
</tr>
<tr>
<td>Lenhovda</td>
<td>109 706</td>
<td></td>
</tr>
<tr>
<td>Stensele</td>
<td>824 841</td>
<td></td>
</tr>
<tr>
<td>Freight transportation from Stensele</td>
<td>1 025 001</td>
<td></td>
</tr>
<tr>
<td>Lenhovda</td>
<td>410 962</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2 471 735</td>
<td>396 295</td>
</tr>
</tbody>
</table>

Table 23. Freight transport costs difference between centralized and decentralized manufacturing structure

6.1.3. How would the environmental cost related to freight transportation be if such a switch occurred?

Due to the Swedish government focus on the CO2 emission to evaluate the environmental cost related to transportation, the authors focused on calculating the amount of CO2 emitted during the different freight transportation activities previously analyzed. In order to assess their environmental costs, the authors found out that switching from a decentralized to a centralized structure, the environmental cost would decrease by 91% (20 420 SEK) due to the decrease of material flow.
6.1.4. Overall consideration

In overall, the findings, highlighted a significant difference in total transportation costs between the actual and supposed structure of Rottne Industri, in favor of the new centralized structure.

<table>
<thead>
<tr>
<th>Transport cost (2012)</th>
<th>Decentralized</th>
<th>Centralized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight Transportation cost</td>
<td>2 471 735</td>
<td>396 295</td>
</tr>
<tr>
<td>Environmental cost</td>
<td>22 390</td>
<td>1 970</td>
</tr>
<tr>
<td>Total transportation costs</td>
<td>2 494 125</td>
<td>398 265</td>
</tr>
</tbody>
</table>

Table 24. Transportation costs differences between centralized and decentralized structure

Indeed, it was supposed that as all activities were to be transferred into one facility, the freight transportation costs between the different plants would disappear (Figure 6 and 7), reducing drastically the overall cost of transportation (Table 24), as well as the reduced distance between the different suppliers. However, the transportation cost represents only one variable which may lead to organizational change. As a matter of fact, top managers at Rottne Industri will have to consider the changes associated with both the switch in structure and other advantages and disadvantages of the new structure. It is suggested by the authors of this thesis that there should be further future research for the changes that are needed to be undertaken by the Rottne management in order to create and maintain the new centralized structure, and are mentioned later on in the conclusion part of this thesis.

One particular point of interest is that the theory concerning the advantages and disadvantages of centralized and decentralized structure is that only some theoretical criteria are positively met. Indeed, the Figure 7 shows that a centralized structure would be easier to manage as less different material flows would have to be planned and followed-up, although their volume will be higher. Moreover, the current decentralized manufacturing structure of Rottne Industri is not based on enabling each of its factories to be responsible for their own logistics activities, purchase, offers and so on.

These discrepancies from the theory are likely due to the fact that Rottne Industri does not consider its plants as business units but mainly as dislocated assembly lines. The transportation related activities are not viewed as an important part of the company’s logistics strategy but as necessary and inevitable activities for the running of manufacturing
operations. However, thanks to the calculation, it is possible to see that an optimization of transportation in a centralized structure can be beneficial in the long run to lower the cost of the final product.

6.2. Further research

Although transportation costs are significantly lower in the centralized structure for Rottne Industri, this decrease in cost alone is not enough to consider switching from the current decentralized structure. Indeed, several other topics have to be taken into consideration, the most important being the investments required to provide the necessary production capacity and all the support activities for the good run of operations.

In addition to the needed investment for production operations, another lead for further research would be to focus on the necessary investment needed for the storage facilities capacity for the increased volume of raw material, spare parts, frames and components. In complement, establishing a new storage layout and the necessary equipment to manage it has to be developed for efficient and effective handling.

More specifically, the new centralized manufacturing structure, commands not only larger storage facilities, but also the creation of a new storage layout in overall, in order to create the best possible conditions for this new centralized structure to produce the greatest possible outcome. Finally, if Rottne industry is to switch its manufacturing structure into a centralized one, management will have to invest also in the necessary equipment needed to manage the material handling in an effective and efficient way, due to the increased incoming materials to the facility, as well as increased mobility of materials within the plant.

The authors suggest that these necessary investments that are needed in order to increase Rottne’s production capacity, modify and expand its storage layout and bring in the necessary extra equipment, should be further studied in the future. This further research for the expansion of the manufacturing facility in Rottne, and the cost of it, will help Rottne Industri’s managers to plan and organize the centralization procedure in a smooth and proactive way. The authors estimate that although the cost of this expansion in storage, equipment and further modifications, is much higher than the savings gained within one
year from the decreased transportation costs, in the long run the cost of the new investments will be covered.

In this thesis the authors have calculated the amount of savings, in money terms per year, gained for Rottne Industri if the management decides to change the company’s manufacturing structure into a centralized one. This change in structure needs to be supported by further investments from the company, as mention earlier. However there will be full amortization for these investments made on behave of the company, and from that point and on Rottne Industri will start seeing the payoff in favor of the company’s financials, by starting to collect the annual savings calculated by the author of this research.
7. References

7.1. Written references


### 7.2. Oral references


Axelsson R., Sales Manager Export, (2013), Interview about transportation costs [Oral communication] (Rottne, 6 May 2013)