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Mapping the usage of returnable packaging material and a proposal for improvements

A Case Study at Haldex AB in Landskrona

Annika Jönsson

2020-12-18

Preface

This M.Sc. Thesis was carried out during the autumn of 2020, as the last part of my Master of Science in Mechanical Engineering at the Faculty of Engineering at Lund University. The thesis was performed in collaboration with Haldex AB in Landskrona.

I would like to give a big thanks to my supervisors at Haldex, Anders Pålsson and Enes Hasic, from whom I have got a lot of feedback and support, which have been truly appreciated. I would also like to thank the rest of the people at Haldex, who I have been in contact with during my thesis, for their time and valuable inputs. Finally, I thank Eva Berg, supervisor at the Faculty of Engineering at Lund University, for her constructive feedback and guidance throughout the thesis.

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Abstract

Title: Mapping the usage of returnable packaging material and a proposal for improvements - a Case Study at Haldex AB in Landskrona

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Problem description: Haldex is using both various returnable packaging solutions and some non-returnable packaging material. Investigating the packaging material flow for the main customers is needed in order to improve the flow. Returnable packaging requires controlling packaging logistics. At the moment, there is not a control system for the packaging material which makes it difficult to follow up and evaluate. Having a control system may help to have control of the reverse flow of returnable packaging material and to be able to keep track of where the stock is, in order to prevent common problems such as shrinkage of packages.

Purpose: The purpose of this thesis is to perform a mapping of the usage of the packaging material flow and how to improve that flow at Haldex.

Research questions:

RQ1: How is the usage of the packaging material flow currently looking?
RQ2: How should Haldex control the packaging material flow in the future?

Methodology: To fulfil the purpose of the thesis, a single-case study approach has been used. Both quantitative and qualitative data coming from company documents, databases and interviews has been used for the report together with a thorough literature study. The objective of the case study was to build an understanding and foundation to conduct an analysis concerning the usage and control of packaging material flow in order to find the optimal solution for Haldex.

Conclusion: The analysis identified losses of returnable packaging material for the customers that was investigated and difficulties to manage the flow. It is recommended to implement a control system to keep track of where the packages, owned by Haldex, are in the flow. A control system will increase the visibility and traceability of the packaging flow in the forward and reverse supply chain and minimize the losses of packaging material.

Keywords: Supply chain, reverse supply chain, returnable packaging material, control system.

Table of Contents

List of Figures

List of Tables

1. Introduction

This chapter describes the background of the master thesis and presents the problem that the company encounters. Next, the purpose is clarified, focus and delimitation of the thesis is presented and which target group the thesis addresses. Finally, the disposition of this report is presented.

1.1 Background

Over the last century companies have strived to optimize their supply chain in different aspects with the objective to reduce cost and increase competitiveness against other companies. But during the past two decades a new topic has been raised in the logistic area, the reverse supply chain. The reverse supply chain is the action and steps to move the goods from customer to vendor. Most companies have reverse flow of goods and the objective is often to reuse or resale the goods. Thus, a reverse logistics system is created. There can be different reasons like sustainability, financial gains or competitive advantages. Therefore, it becomes increasingly important for companies to create a good flow of returnable material. (Mollenkopf et al., 2005; Lumsden, 2012; Larsen, 2017)

The usage of returnable packaging has increased in different industries because of the benefits compared to one-way packaging. Companies invest in returnable packaging to reduce packaging waste, costs, transport damage and improve productivity of assembly lines. The need to constantly purchase packaging material is eliminated by using returnable packaging. Additionally, logistics operational costs can be reduced by more efficient handling and cube utilization in transport and in the warehouse. On the other hand, using returnable packaging makes the supply chain more complex to control due to also including the reverse flow. Initial investments are high, additional transport cost for the returns and need to handle and sort the empty packaging. There are several factors, such as costs, efficient allocation, delivery distance to consider whenever using returnable packaging or non-returnable packaging. (Byungsoo, Min Kyu, Won Ju, 2019; Johansson & Hellström, 2010; Mollenkopf et al., 2005)

1.2 Problem formulation

Haldex is a global company within the commercial vehicle industry, manufacturing brake systems and air suspension solutions for heavy vehicles. The company was founded in Landskrona in 1887. Currently, the company has more than 2.200 employees operating in 19 countries, has a net sale of SEK 5,151 million and has customers in North America, Europe, and

Asia. Having safe, profitable growth, quality, and sustainability as its core values, Haldex aims to use the resources efficiently, while delivering high quality products to its customers. Having the continuous improvements mindset, the company aims to optimize the packaging material flow, from an economic, sustainability and service performance perspective.

Haldex Brake Products AB has many different product variants, approximately 50 variants, and handles over 400 different components. The coming years the volumes for the disc brakes are increasing and material flows are becoming more complex due to subcontracting of some parts. Then the packaging material flows, both regarding returnable and non-returnable packaging material, becomes even more important to keep track of. To handle the wide packaging material flow that also will increase in the coming years, it is vital to make the right decisions considering various aspects, both from a logistic and financial perspective.

Currently, Haldex is using both different returnable packaging solutions and some non-returnable packaging material. Investigating the packaging material flow of both reusable packaging and non-reusable packaging used at the moment are needed in order to optimize the packaging material flow and suggest solutions on how to improve the flow.

Returnable packaging requires controlling packaging logistics, i.e. having the right amount of packaging material at the right place at the right time while minimizing costs. At the moment, the control of the packaging material is a bit inadequate which makes it difficult to follow up and evaluate. Having a control strategy may help to have control of the reverse flow of returnable packaging material and to be able to keep track of where the stock is, in order to prevent common problems such as shrinkage of packages.

1.3 Purpose and research question

The purpose of this thesis is to perform a mapping of the usage of the packaging material flow and how to improve that flow at Haldex. To fulfil the purpose, the following research questions needs to be answered:

RQ1: How is the usage of the packaging material flow currently looking?

RQ2: How should Haldex control the packaging material flow in the future?

1.4 Focus and delimitations

Delimitations are needed in order to define the scope of this thesis and to have a number of aspects that can be dealt with, within the limited time frame and given resources. Therefore,

delaminations have to be determined. The delimitations described in this chapter originate from discussions with the supervisors at Haldex.

The focus of the master thesis is to perform a mapping of the usage of packaging material, in order to suggest how to improve that flow. Both returnable and non-returnable packaging material will be considered. Furthermore, to propose a solution for how Haldex in the future can keep track of where the stock is. A delimitation that will be made is that only the main customers will be investigated when mapping the packaging material flow. The thesis will evaluate the packaging flow from Haldex to their main customers and the reverse flow. Another delimitation is that the suppliers will not be investigated.

1.5 Target group

The target group of this thesis is people with interest and knowledge in supply chain management, logistics and reverse supply chain. The main target group is the logistic department at Haldex AB.

1.6 Report structure

Chapter 1- Introduction
This chapter describes the background of the master thesis and presents the problem that the company encounters. Next, the purpose is clarified, focus and delimitation of the thesis is presented and which target group the thesis addresses. Finally, the disposition of this report is presented.

Chapter 2 - Methodology
This chapter describes different methodology options and explains the research strategy for this master thesis. The chapter begins explaining several research approaches. Then moves to the research strategy chapter explaining relevant research strategies. Further, different data collection methods and the credibility of the research is discussed. Finally, the research process for this thesis is illustrated and described with regard to chosen research strategy.

Chapter 3 - Literature Review
This chapter describes theory from current research within the area of packaging logistics, focusing on the reverse supply chain and control systems. The theory is presented to give a solid understanding of the packaging system of the supply chain.

Chapter 4 - Empirical Study
This chapter presents the empirical findings for this thesis. This chapter is structured as follows: description of Haldex, current packaging system, supply chain of packaging, packaging material handling process, activities related to packaging at Haldex. Lastly, the findings about the customers are presented.

Chapter 5 - Analysis
This chapter presents the analysis of the packaging material flow in order to increase the control. The analysis is based on existing theory and empirical data in regard to the research questions.

Chapter 6 - Recommendation
This chapter presents the recommendations to Haldex. The recommendations are connected to research question two.

Chapter 7 – Conclusion
In this last chapter the conclusion of this master thesis is presented. Firstly, the research questions are answered. Afterwards possible future research fields are suggested. Lastly, contribution to theory is discussed.

2. Methodology

This chapter describes different methodology options and explains the research strategy for this master thesis. The chapter begins explaining several research approaches. Then moves to the research strategy chapter explaining relevant research strategies. Further, different data collection methods and the credibility of the research is discussed. Finally, the research process for this thesis is illustrated and described with regard to chosen research strategy.

2.1 Nature of research

There are different forms of research methodologies and which methodology that can be used depend on the purpose of the research (Runeson & Höst, 2009). The four most common methodologies, according to Höst, Regnell, and Runeson (2006), are presented below:

- Exploratory: explore a research area which has little or no information and to clarify fundamental nature with the objective to attain a fundamental understanding.
- Descriptive: describe a phenomenon or a situation. The method is used when there already is a fundamental knowledge and understanding of the field.
- Explanatory: explain a phenomenon or a situation, seek an informative description. The objective is to attain a deeper knowledge.
- Problem-solving: intention to find a solution to an identified problem.

At the moment, Haldex does not have a system to keep track of where the packaging material stock is. This thesis arose with the goal to optimize and improve the packaging material flow and create a solution where Haldex can keep track of where the stock is. With this fact the research is considered to be problem-solving.

2.2 Research approach

There are different levels of abstraction when writing assignments, where the extremes are the general (theories) on one side and the concrete (empirical data) on the other side. There are two different research approaches, inductive and deduction, and a combination of these two, i.e. balanced approaches. These approaches are described below, and the steps illustrated in Figure 1 below.

2.2.1 Inductive

According to Kotzab et al. (2006), the inductive approach objective is understanding and explaining a phenomenon. In an inductive approach, one is working from a more detailed view (facts) to more general perspective (theory). Briefly, the inductive approach starts in reality with data collection, for example by doing field visits observing the phenomenon in its natural settings. The second step is description of the phenomenon, where patterns are attempted to be discovered. Lastly, the patterns can be summarized in models and theories, i.e. the outcome is a substantive theory. In an inductive approach, the field can be researched empirically before reading and studying existing theories. Theory is formulated based on the collected data. (Björklund & Paulsson, 2014; Kotzab et al., 2006) The inductive approach is illustrated to the left in Figure 1.

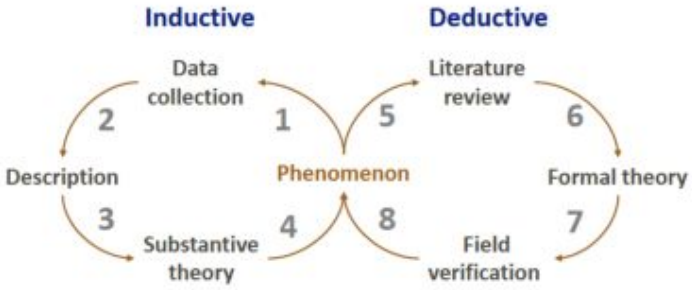

Figure 1. The Inductive and Deductive Approach (Source: Woodruff (2003) referred to in Olhager (2020)).

2.2.2 Deductive

Within the logistics and supply chain phenomenon, the deductive approaches are the most used according to Kotzab et al. (2006). The deductive approach aims to add on to the existing knowledge, describe and predict the phenomenon. The deductive approach is illustrated to the right in Figure 1 and as the figure shows the approach begins with a literature review and building a conceptual framework where variables are specified as well as relationship between them. The second step is to create a formal theory based on exciting research and predictions about the empirical material are made. Before entering the last step, the researcher proposes answers to the research questions. Lastly, data is collected to verify the formal theory with the aim to compare and test the strength of the proposed relationship between variables. (Björklund & Paulsson, 2014; Kotzab et al., 2006)

2.2.3 A balanced approach

There is an alternative to be between the inductive and deductive approaches, which is then called a balanced approach, according to Kotzab et al. (2006). A balanced approach, also called abduction approach, is achieved in research by tracking backward and forward between inductive and deductive approaches, i.e. between the different levels of abstraction (Björklund & Paulsson, 2014; Kotzab et al., 2006). According to Kotzab et al. (2006), when a new or complex phenomenon is researched it is appropriate to start with understanding the phenomenon, i.e. an inductive approach is suitable, and later testing formal theory and potential relationship between variables, i.e. deductive approach. Therefore, this results in a combination of inductive and deductive, where the circular path is crossed over to the other approach in the circles in Figure 1.

2.2.4 Selected approach

In this thesis, a combination of inductive and deductive approach will be used, tracking back and forth among them. In line with what Kotzab et al. (2006) describe, different views of the supply chain are provided when using both an inductive and deductive approach. An extensive understanding of the problem can be achieved in this project by empirical studies and literature review simultaneously. The problem will first be fully understood, before the formal theory is studied, followed by a field verification and eventually adjustments. Therefore, a balanced approach, tracking backward and forward, is appropriate for this thesis to attain a comprehensive understanding of the problem.

2.3 Research strategy

2.3.1 Research strategies

There are different research strategies, and the choice of research strategy depends on the research questions according to Saunders et al. (2009). This is further elaborated by Yin (2018), who states three conditions which distinguish the different strategies. These conditions should be considered when deciding what strategy to use. The tree conditions are stated in Table 1 below and their relationship to the five research strategies: experiment, survey, archival analysis, history, and case study. (Yin, 2018) An experiment is aiming to find causation and explain root-causes when studying a single variable. A survey is a method to collect data by questionnaire consisting of several standardized questions and alternative answers, aiming to describe or explain a phenomenon. An archival analysis involves seeking and extracting information from original archival records. History research is used to study non-contemporary events, i.e. the “dead” path. Case study is used to study contemporary phenomena and aims to describe a phenomenon or an object in the deep. (Höst, Regnell, Runeson, 2006; Yin, 2018)

Table 1. Relation between research strategy and the three conditions stated by Yin, 2018.

Research strategy	**Form of research question**	**Requires control over behavioral events?**	**Focuses on contemporary events?**
Experiment	How, why?	yes	yes
Survey	Who, what, where, how many, how much?	no	yes
Archival analysis	Who, what, where, how many, how much?	no	yes/no
History	How, why?	no	no
Case study	How, why?	no	yes

The strategies can be used separately, i.e. one by one, but they can as well be used mixed in an integrated mode. Using several strategies can help address more complex research questions and strengthen and improve the quality of the research. (Eisenhardt, 1989; Saunders et al., 2009; Yin, 2018) For example, different views of the supply chain are provided and relationships can become clearer when using a combination of qualitative and quantitative data collection strategies (Kotzab et al., 2006).

2.3.2 Selection of research strategy

In this thesis, the research questions are both "how"-questions. How the packaging material flow is currently looking and then a question that suggests a solution to the problem with the flow. As illustrated in Table 1 above, the "how" questions are linked to either experiment, history, or case study. Using an experiment is not applicable to this study due to many variables involved in the packaging flow and possibilities for a control system. However, a history research strategy is appropriate when the focus of the research is on non-contemporary events, i.e. the past (Saunders et al., 2009). Historical data and theory are used in this project, but principally concerning literature review and quantitative analysis and none of them is used to study historical changes. Further, the case study research strategy is suitable when a contemporary event is researched, and a phenomenon should be described in its nature. It is possible to use multiple sources in case studies and both quantitative and qualitative data can be used, which is not possible with, for example surveys or archival analyses alone. (Voss et al., 2002; Yin, 2018) A case study can consist of a single or multiple case. A single and multiple case study can either be holistic or embedded. A holistic single- or multiple case study involves a single unit of analysis while an embedded involves multiple units of analysis, i.e. units of analysis at more than one level. Embedded case studies happen when there are subunits within a case. (Yin, 2018) Since this thesis is about the usage of the packaging material flow for the main customers, the analysis includes data from several customers, i.e. subsections, meaning that the case is an embedded

research. This also means that the unit of analysis is defined as the usage of the packaging material flow, including how to control it. The facts about embedded single-case studies correlate well to the research required of this thesis in order to answer the research questions. Therefore, the case study has been chosen as the research strategy.

2.4 Research data

The quality of the research is affected by the quality of the data used in the study. Therefore, it is important to have high-quality data. Data can be either qualitative, quantitative or a combination of both and the data is categorized into primary or secondary sources. (Björklund & Paulsson, 2014) There are several different data collection methods. When collecting data in a case study, it is possible with a combination of several gathering techniques to study the phenomenon. Using multiple sources of data strengthens the reliability of the collected data. (Voss et al., 2002)

2.4.1 Quantitative and qualitative data

Research data can either be quantitative or qualitative. The main difference is that quantitative data is data in numbers and qualitative data is non-numerical or soft data (Wallén, 1993). *Quantitative data* consists of information that can be measured or classified, such as number, proportion, weight, etc. Statistic methods can be used to process quantitative data. However, all data cannot be measured or evaluated numerically and therefore knowledge has to be generated in another way, i.e. qualitative studies. *Qualitative data* consists of words and descriptions rich in details. Qualitative data can be processed by analyzing the data through sorting and categorizing. A combination of both qualitative and quantitative data is often used for complex problems, where the quantitative data consists of numbers and the qualitative data consists of for example interviews. (Höst et al., 2006; Björklund & Paulsson, 2014)

Both quantitative and qualitative data will be used in this thesis in order to attain knowledge and understanding of factors that are not only measurable and numerical. A combination is most suitable for this study.

2.4.2 Literature review

Literature is defined by Björklund & Paulsson (2014) as all forms of written and reproduced material, for example, books, magazines, articles, and brochures. The information that can be collected from literature studies is called secondary data, i.e. the facts and information have generally been created for another purpose than for the current study. (Björklund & Paulsson, 2014) The literature search is normally done in several rounds during the work with the master thesis. The literature search begins with a broader search, using various databases and keywords related to the research area. After the initial search, a selection of references is done, and the

relevant sources are studied deeper. Then, a more depth and focused search is done commonly using the reference list from the relevant sources. After finishing the literature search, the review can start. The literature review has different purposes through the work path with the mater thesis. In the beginning of the process, the focus is on obtaining knowledge about the subject. Later, it is appropriate to return to the literature to compare results. (Höst et al., 2006) The strength of literary studies is the possibility to gain a lot of information in a short time and small or non-economic resources are needed. (Björklund & Paulsson, 2014)

This thesis will conduct the literature search using the strategy described above from Höst et al. (2006) and after the literature search is finished, the literature review starts. The objective with the literature review is to gain knowledge about the packaging logistics, reverse supply chain and control systems regarding returnable packages.

2.4.3 Interviews

Interviews consist of various kinds of questioning about a specific theme and can be done in direct contact, via telephone, via e-mail, etc. Interviews provide primary data, i.e. the data is collected with the purpose to be used in the current study. There are several different forms of interviews. Interviews can be structured, semi-structured or unstructured and these different forms are explained below. (Höst et al., 2006; Björklund & Paulsson, 2014)

- Structured interviews: all questions are defined before the interview and the questionnaire is precisely followed. It is like an oral survey and the objective is to perform all interviews similar to each other.

- Semi-structured interviews: questions are defined before the interview, but the order and formulation can be changed. The interviewer decides whenever it is suitable to take up a question. This type is more open compared to a structured interview.

- Unstructured interviews: the interviewer controls the interview and the questions; no preparations are necessary because the questions come up along the interview. The form is of the type conversation.

This thesis will use both semi-structured interviews and unstructured interviews. The reason for this is to understand the packaging material flow from different points of views, but also obtain a deep understanding of the problem. This is achieved by having the possibility to ask follow-up questions, which can be done during semi-structured interviews but not during structured interviews. The semi-structured interviews were prepared with some guiding questions. The unstructured interviews, where the form is more of the type conversation, were performed to get information about the packaging flow, customers, and control system. The interviews were performed with people who have different responsibilities within the process of packaging material flow, i.e. people working with logistics, shipping, warehousing and production at Haldex. The questions that were asked during the interviews can be found in the appendix.

2.4.4 Data collection at Haldex

Corporate documents from Haldex are used to understand the business and the current situation of the supply chain system and especially the flow of packaging material. The documents consist mainly of numerical data in Excel sheets and delivery notes from returns, but also some documents in the form of literature. Since some of the data are company secret, some numbers and facts will not be included in the publication of this thesis. Information about the packaging flow and the packages was also collected through informal conversation with different persons at Haldex. Other data collection methods, which were used in smaller scale during the project, were attendance at meetings, informational meetings, and observation of how the company is working, to understand different processes within the company.

2.5 Credibility

There are three main categories of measuring the credibility of a study. These aspects have to be considered in scientific context. The three concepts are described below. (Björklund & Paulsson, 2014; Yin, 2018)

- Validity: how accurate you measure what is intended to be measured.
- Reliability: how reliable the measuring instruments are, i.e. the degree of receiving the same results if the investigation is done again.
- Objectivity: the extent to which the study is not affected by the authors. The conclusions are general and based on facts and data, rather than personal opinions and beliefs.

In a study, one should aim to attempt to get as high validity, reliability, and objectivity as possible (Björklund & Paulsson, 2014).

2.5.1 Increasing credibility

The three aspects, validity, reliability, and objectivity can be increased in several different ways. Thus, by using various perspectives, for example triangulation, the validity can be increased. For instance, when using interviews or surveys, one can specify the target group and have clear questions in order to increase validity. Regarding increasing the reliability, control questions can be used in interviews and surveys in order to examine the aspects once more. Triangulation can as well be used to increase the reliability of a study. The objectivity of a study can be increased by explaining and motivating the choices made in the study. This makes it possible for the reader to take its own stand with regard to the results. (Björklund & Paulsson, 2014)

2.5.2 Triangulation

The reliability of the research can be increased by using different perspectives and sources to investigate a phenomenon. Using multiple methods to study the object in order to increase the credibility of the study is called triangulation. Figure 2 illustrates triangulation. Triangulation provides several different perspectives and contributes to obtain a more comprehensive understanding of the phenomenon of the study. (Björklund & Paulsson, 2014)

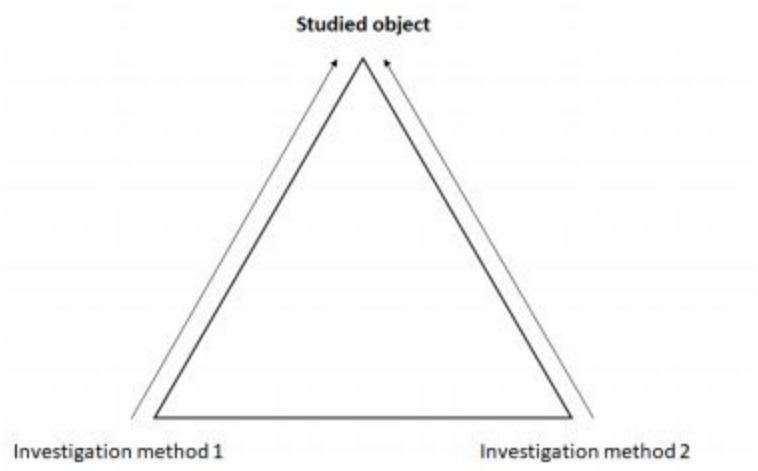

Figure 2. Illustration of triangulation (Source: Björklund and Paulsson (2014)).

According to Björklund and Paulsson (2014) there are several types of triangulation and the authors mention tree types. Data-triangulation refers to using various sources of data. Further, when different theories are used or applied on the same data, it is called theoretical triangulation. Evaluator-triangulation means that different people (i.e. evaluators) are used for the evaluation of the situation or material in order to obtain different perspectives.

The reverse supply chain with returnable packaging material is a relatively new research topic. To strengthen this new research area, theoretical triangulation is used to increase the reliability of the study. Data triangulation will be used to achieve good credibility, i.e. validity, reliability, and objectivity. Since, questions to several different people involved in the packaging flow will be conducted and control questions will be asked, the risk of misleading will be decreased.

2.6 Research process

The research process model of this thesis is divided into three steps, illustrated in Figure 3. The first step is to get an understanding of the problem, the company - Haldex and related theory. The second step is collection of data at Haldex, building a deep understanding of how the flow of

packaging material is working and managed. The last step includes analyzing the information and drawing conclusions from that, before finishing the report with a thread throughout it.

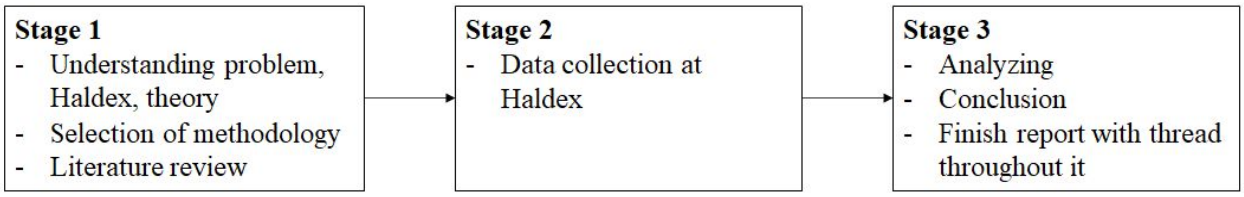

Figure 3. The three steps in the research process.

2.6.1 Stage 1 - Define and design

The study started with an introduction to Haldex, their business model, their customers and packaging system. The foundation of the understanding was built by a literature review, conversations, and interviews. Later, the methodology was selected.

2.6.2 Stage 2 - Data gathering

The second stage was data collection which consists of gathering information and data from internal documents. Some data was also collected from the customers through contacts at Haldex. The report was continuously updated during this phase.

2.6.3 Stage 3 - Analysis and conclusion

The last stage of the research process began with analyzing the empirical data that was collected in the previous step. The analysis was done as an embedded single-case study and the customers were analyzed one by one. A comparison among the literature and empirical data were also done. This in order to answer the research question and create a recommendation. Then, all was summarized in the conclusion. Lastly, the report was finished with a common thread throughout it.

3. Literature review

This chapter describes theory from current research within the area of packaging logistics, focusing on the reverse supply chain and control systems. The theory is presented to give a solid understanding of the packaging system of the supply chain.

3.1 Supply Chain

3.1.1 Definition of supply chain

There are many definitions of supply chain in different literature. According to Mentzer et al. (2001) supply chain is defined as following:

"A supply chain is a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer".

A supply chain is a network that links the company with suppliers, trading partners and customers throughout organizations in order to produce and distribute a product or service. Supply chain is usually viewed as a forward chain where the final destination is the end customer. But many times, there also is a reverse supply chain, i.e. from customer to vendor. (Bowersox, Closs, & Cooper, 2010; Mentzer et al., 2001)

3.1.2 Supply chain mapping

Supply chain maps are defined as "a representation of the linkages and members of a supply chain along with some information about the overall nature of the entire map" according to Gardner and Cooper (2003). Supply chain maps can be designed in many ways and the focus, scope and level of detail in the maps can vary. The maps can be useful for different reasons in a firm, hence the purpose of doing supply chain maps also varies. The maps can describe organizations, facilities, flows, and/or processes. (Gardner and Cooper, 2003)

Supply chain mapping is a useful tool to get an overview and understanding of the supply chain by visualization of information. The map works as graphical support for visualizing the supply chain or a specific area of interest within the supply chain. By mapping the area, it is possible to find areas for deeper analysis and evaluate the current supply chain to find areas for improvements. (Gardner and Cooper, 2003) It is a tool to identify problems in the supply chain and can as well be used as a proactive tool to recognize critical paths and dangers, and try avoiding them (Wichmann, 2020). A supply chain map will form the basis for changes and redesign of the supply chain. The map should contain key information and right information that

is easily displayed so it is easy to understand the map in order to find critical suppliers. A well-constructed map has the following characteristics: “interpretable, recognizable and in an easy-to-disseminate format”. (Gardner and Cooper, 2003)

3.2 The reverse supply chain

The reverse supply chain is the flow of products from customer back to vendor, i.e. the opposite to the traditional supply chain. The reverse supply chain can be a return system for final products as well as for packaging material (Larsen & Jacobsen, 2016; Guide Jr & Van Wassenhove, 2002)

There are several reasons for the increased interest in the reverse supply chain in the last two decades, such as higher prices of raw material which makes reuse beneficial due to decreased purchasing cost, sustainability, environmental regulations or pressure from customers. Therefore, reusable packages and material is used instead of one-way packaging. (Larsen, 2017; Van Wassenhove, 2002) There are different purposes of reverse supply chain, for example resale of products or reuse components in the operations. Resale of products contributes to revenue and reuse components decrease purchasing costs of new components. These examples show that reverse supply chain affects the company's financial performance. (Larsen, 2017) But there are challenges having a reverse supply chain. For example, create new points of contact with the customers, educate the customers, decide which activities should be outsourced respectively performed in house. However, the main question is how to minimize costs while finding innovative ways to recover value. Additionally, environmental regulations sometimes also need to be considered. (Guide Jr & Van Wassenhove, 2002)

The reverse supply chain can be divided into five key processes, described below, and illustrated in Figure 4. By analyzing options, costs, and benefits for every process, rational decisions regarding the structure of the reverse supply chain can be taken. (Guide Jr & Van Wassenhove, 2002)

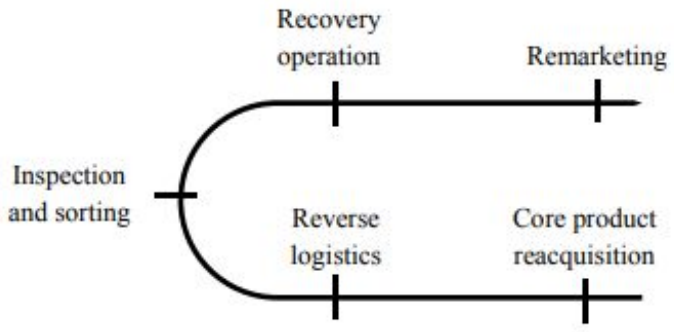

Figure 4. The reverse supply chain (Source: Larsen and Jacobsen (2014)).

Product acquisition: the reverse chain starts with reacquiring the used products from the customer. The quality, quantity, and timing of the returned goods have to be managed carefully. In contrast to forward supply chains, the quality and quantity of returned products are unpredictable and can vary from time to time. Thus, companies generally need to work closely with the customers for efficient returns. (Guide Jr & Van Wassenhove, 2002)

Reverse logistics: the second process includes the transportation of products, bringing them back from the customer to a facility for inspection, sorting and disposition. The design of the reverse logistic network varies depending on the involved goods characteristics, such as bulkiness, fragileness, and economic value. Factors that also should be considered is the cost for shipping and storing the products as well as the need for control of the returned goods. (Larsen & Jacobsen, 2014; Larsen, 2017; Jr & Van Wassenhove, 2002)

Inspection, sorting, and disposition: constitutes the third step. When the products have been collected, it is time for evaluation of their conditions and determine the reconditioning operations. This process is a time-consuming task, but the process can be more effective by using for example quality standards, bar codes and other technologies to automate tracking and testing of the returned goods. Disposition decisions should be made as early as possible in the return process and are based on product complexity, quality, and other variables. (Larsen & Jacobsen, 2014; Guide Jr & Van Wassenhove, 2002)

Recovery operations: the fourth step in the reverse supply chain covers the process of reconditioning the returned products for reuse or resale. There are different recovery processes, and which is most suitable depends on the function of the reverse supply chain. Product recovery processes include for example, repairing, refurbishing, or remanufacturing. More operation may be cleaning, disassembly, exchange of components and reassembly. (Larsen & Jacobsen, 2014; Guide Jr & Van Wassenhove, 2002)

Distribution and Sales: the fifth step is remarketing of the products. The recycled product is distributed to either the original market or a new market is created. There may exist a market for recovered products for both original purchasers and new customers, as well as customers who cannot afford new products. (Larsen & Jacobsen, 2014; Guide Jr & Van Wassenhove, 2002)

If the forward and reverse supply chain is considered at the same time, this network creates a closed-loop system (Govindan, Soleimani, & Kannan, 2015). Commonly, companies that are successful with their reverse supply chains have integrated it with their forward supply chain. This means that a holistic approach is applied, the design of products and manufacturing decisions are made having eventually recovering operations in mind. (Guide Jr & Van Wassenhove, 2002).

3.3 Logistics

According to CSCMP logistics is defined as:

"Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements."(Council of Supply Chain Management Professionals (CSCMP), https://cscmp.org/, 2020-10-03)

Logistics can have many functions depending on the industry. Logistics includes activities that are integrated throughout a network of facilities. The logistics activities in the network are the combination of the company's order processing management, inventory, warehousing, material handling, packaging, and transportation. Coordinating logistics activities with other functions within the firm, such as manufacturing, physical distribution, marketing, purchasing, sales, and finance, into an integrated supply chain is needed, but it can be challenging for the company. (Bowersox, Closs, & Cooper, 2010; Cooper et al., 1997)

3.3.1 Transportation

Transportation refers to the operational area of logistics that moves products from one location to another (Bowersox, Closs, & Cooper, 2010; Chopra, 2019). Transportation is an important part of the logistics because of globalization where both customers and suppliers are located in different parts of the world. There are several criterias that have to be considered when choosing the mode of transport, however cost is a key criteria. (Chopra, 2019) Other criterias that also is considered is speed of transportation, shipment distance, capacity (shipment size), type of product and risks. The principal trade-offs in transportation are between cost and speed of transportation. (Bowersox, Closs, & Cooper, 2010; Sheffi, Eskandari, Koutsopoulos, 1988)

3.3.2 Warehouse and activities

Warehouses are a fundamental part of the supply chain. The main role contains: keep the buffer of material flows along the supply chain to handle variability caused by different factors such as product seasonality or batching in production and transportation, consolidate goods from different suppliers and value-added-processing as for example sorting, labeling, and packaging. (Gu et al. 2007) Generally, warehouse processes and activities include receiving, put-away, sorting, storing, picking, packaging and shipping (Kembro, Norrman, Eriksson, 2018; Gu et al. 2007; Bowersox, Closs, & Cooper, 2010). In order to do these operations effectively and efficiently it is necessary to consider several design aspects and resources, such as physical layout, storage and handling equipment, automation solutions, information systems and labor management (Kembro, Norrman, Eriksson, 2018).

3.4 Packaging

According to European Parliament and Council Directive 94/62/EC packaging is defined as:

"'Packaging' shall mean all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. 'Non-returnable' items used for the same purposes shall also be considered to constitute packaging."

Packaging is a considerable part of the logics system and one of the key logistics activities (Stock and Lambert, 2001). Packaging affects the logistics cost and performance, particularly transportation and warehousing (Bowersox, Closs, & Cooper, 2010; Mollenkopf et al., 2005). The requirements on packaging can be derived from the product and its surrounding. Johansson et al. (1997) propose three main groups of requirements, which are flow, market and environmental. Several authors state fundamental functions of packaging as: containment, protection, unitization, information communication, apportionment, convenience (Pålsson, 2011; Robertson, 1990; Lockamy III, 1995). Further depending on function, packaging can be divided into three different levels: primary, secondary, and tertiary level. These levels can be described as following: (Hellström & Saghir, 2007; Chan, Chan, Choy, 2006; Verghese & Lewis, 2007)

- *Primary packaging:* is the basic package that is in direct contact with the product. It is used for consumer packages.
- *Secondary packaging:* contain several primary packages and are used as outer/retail packaging.
- *Tertiary packaging:* is the transport package used to ship goods, normally containing several primary or secondary packages on a roller container or pallet. Special importance of functional and shipping performance.

3.4.1 Returnable packaging

The Returnable Packaging Association (RPA) defines returnable packaging as follows:

"Reusable transport packaging generally includes pallets, bins, tanks, intermediate bulk containers (IBCs), reusable plastic containers (RPCs) and other hand-held containers and totes, trays and dunnage that move products efficiently and safely through supply chains. Reusable transport packaging is constructed of durable materials such as metal, plastic or wood and is designed to achieve multiple uses through rigorous operations and logistics systems."

Returnable packaging is a form of packaging that can be reused several times before it is rejected. There are different types of returnable packages, as for example pallets, slip-sheets, or plastic containers (Kroon and Vrijens, 1994). There are economic, social, and environmental benefits of using returnable packaging. The advantages of using returnable packaging is for example better protection of the products, legislation and environmental benefits and decreased costs, etc. On the other hand, disadvantages are investment cost, transportation costs, flow management storage etc. There can be losses of returnable packages due to damage, misplacement or lost. (Zhang et al., 2015)

3.4.2 One-way packaging

One-way packaging materials are packaging that only can be used one time, for example cardboard boxes. But other materials than cardboard, for example wood, can as well be used for one-way packaging (Kroon and Vrijens, 1994). One-way packaging is normally discarded and recycled or land-filled after being used once (RPA, 2020).

3.4.3 Packaging logistics

Packaging has an impact on different parts in the supply chain and therefore the term packaging logistics have arisen. According to Chan et al. (2006) packaging logistics is defined as "the interaction and relations between the logistics and the packaging system that improve "add on" values to the whole supply chain from raw material producer to end-user, and the disposal of the empty package". The objective is to develop and create a packaging system that supports the logistics process and at the same time satisfies the customers (Dominic, et al., 2000).

Packaging interacts with logistics, manufacturing, marketing, and information systems and consequently influences the supply chain in different aspects. Therefore, packaging has a big impact on logistics costs. Packaging has an impact on logistics costs regarding aspects, such as damages, cargo handling and resources used for controls. Furthermore, both the quality and performance of packages affect the warehousing costs as well as the information on the packages. More logistics activities that are affected by the packaging are, efficiency of warehousing, manufacturing, and transport processes. Thus, by improving the packaging design regarding efficiency and effectiveness, logistics costs can be reduced. (Chan, Chan, Choy, 2006; Pålsson, 2011)

3.5 Control Systems for Returnable Packaging

Although the concept of returnable packaging has increasingly been adopted by the industry lately, the literature about categorization of return logistics systems is referring to the study of Kroon and Vrijens (1995). Several recent articles that describe control systems for return

logistics, such as Hellström & Johansson (2010), Mahmoudi & Parviziomran (2020), all refer to Kroon and Vrijens (1995) work. Kroon and Vrijens (1995) divide the control systems in three categories: switch pool systems, systems with return logistics, and systems without return logistics.

Switch pool systems: all partners have an allotment of containers and are responsible for their own allotment, i.e. cleaning, maintenance, control and storage are every participant's responsibility. The partners can either be sender and recipient or sender, carrier, and recipient. In the first set-up, there is a direct switch of containers and the sender is responsible for the return flow. In the second set-up, there is a switch of containers at every exchange between the partners and the carrier is responsible for the return flow.

Systems with return logistics: include third party ownership, in which a central agency owns the containers and is responsible for the return flow after the recipient has emptied them. The recipient has to bundle the empty containers and store them until a cost-effective collection is reached for return. There are two types of designs of systems with return logistics - transfer system and depot system:

- *Transfer system:* the same containers are used by the sender. The third party is responsible for the return flow from the recipient to the sender. The sender is responsible for tracking, management, cleaning, maintenance, storage, and stock levels.
- *Depot system:* the excess of containers is stored by the central agency at container depots. The sender is provided with containers from the depot. The empty containers are collected from the recipients and transported to the depot. The central agency is responsible for the cleaning and maintaining the containers at the depot. There are two variants of the depot system:
    - *Book system:* The central agency controls the flow of containers in detail. The sender has an account with the agency, where the number of containers shipped and received are credited respectively debited in the sender's account. Therefore, the sender needs to provide the central agency with necessary data for the shipments. This lets the agency control the movement of packages.
    - *Deposit system:* The sender pays a deposit to the central agency for the containers delivered to the sender site. The deposit is at minimum equal to the container value. The sender charges the receiver for the deposit, and the receiver charges his recipient, and so on. The central agency collects the containers when they arrive at their last destination in the chain and pays back the deposit to that party. Shrinkage of the container is financed with the deposit. The deposit motivates fast returns of the containers.

Systems without return logistics: a central agency owns the containers, and the sender rents them. Excess of containers are returned to the agency. The responsibility of returning the containers, cleaning, maintenance, and storage them, lies on the sender. By renting just the amount of containers needed, the sender can decrease fixed costs.

3.5.1 Tracking system

In many industries, there are problems with returnable packaging material such as shrinkage and unpredictable return flows both regarding time and quantity (Kim and Glock, 2014). Therefore, it is necessary with visibility and a proper management approach of returnable items in order to enhance both the process efficiency and control of the returnable items. To fulfill this, a technology is required for tracking and tracing the returnable items. There are several technologies for tracking returnable items which have varying levels of advancement and automation. (Ilic et al., 2009) In general, there are three main systems for tracking returnable flow, which are manual, paper-based systems, barcoding systems, and auto-ID automated tracking. The manual, paper-based systems is based on using a log or spreadsheet to track the status of the returnable items throughout the process. The barcoding system has been used for many years and tracks information about the orders. However, both options, manual-based system and bar code scanning require employees to perform the work with the log/spreadsheet respectively physical scanning of the barcodes. (Ilic et al., 2009; Hellström, 2009) A more advanced technology is auto-ID automated tracking, particularly radio frequency identification (RFID) which can track the returnable packaging position in the supply chain. This technology is proposed in several articles, for example Johansson and Hellström (2007), Hellström (2009), and Kim and Glock (2014), to improve efficiency, information and return predictability and reduce mistakes in the flow of returnable packaging. (Kim and Glock, 2014; Zhang et al., 2015)

3.6 Conceptual model

A conceptual model has been developed by the author, shown in Figure 5, using the theoretical concepts presented above which are relevant to the research questions and the purpose of the master thesis. The model helps the reader to visually understand the relevant topics and context for this study, which is control of the packaging material flow. Figure 5 presents the variables like manual system, barcode and automated system that will be considered for analyzing how to control the forward and reverse supply chain of the returnable packaging material at Haldex. It also shows the flow of orders, information, and payment from the Haldex in Sweden to the customers in Europe and Middle East.

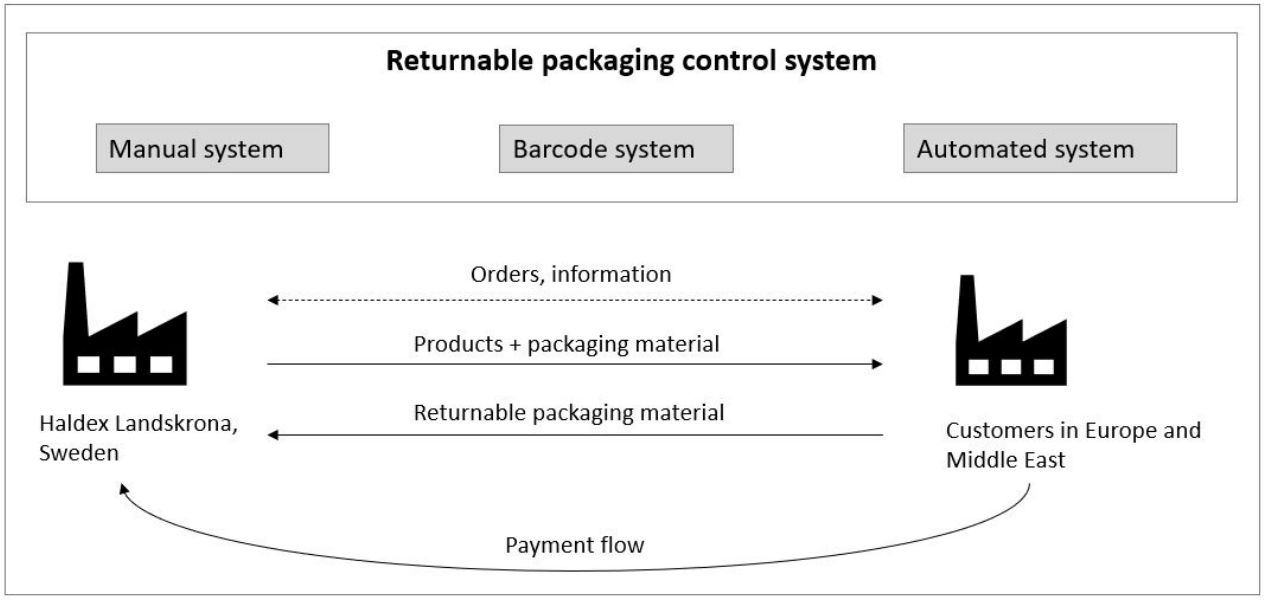

Figure 5. Conceptual model.

4. Empirical study

This chapter presents the empirical findings for this thesis. This chapter is structured as follows: description of Haldex, current packaging system, supply chain of packaging, packaging material handling process, activities related to packaging at Haldex. Lastly, the findings about the customers are presented.

4.1 Haldex Background

Haldex is a global company within the commercial vehicle industry, manufacturing brake systems and air suspension solutions for heavy vehicles. Currently, the company has more than 2.200 employees operating in 19 countries. Production units are located in Sweden, Hungry, India, Mexico, United States, Germany, China and Brazil. Haldex head office is located in Landskrona where the manufacturing of bake systems is placed. Operating income for 2019 was SEK 105 million and with an operating margin of 2.0 percent.

The core segments of Haldex operations are brake system and air control system, and the division between the segments is shown in the pie chart to the left in Figure 6. The customers are principally large manufacturers of trucks, buses, and trailers. Haldex largest market is North America followed by Europe, Asia, and the Middle East and lastly South America. The sales division between the regions is shown in the middle pie chart in Figure 6 below. The aftermarket is the biggest customer category of sales, followed by trailers and heavy trucks, illustrated in the pie chart to the right in Figure 6 below. Haldex offers spare parts, training and servicing to distributors, workshops, and logistics companies on the aftermarket. The selling of spare parts and service to the aftermarket is for repairing and service vehicles. The aftermarket, which Haldex delivers to, consists of truck and trailer manufacturers' own distributors as well as independent distributors. The distributors resell to workshops and logistics companies.

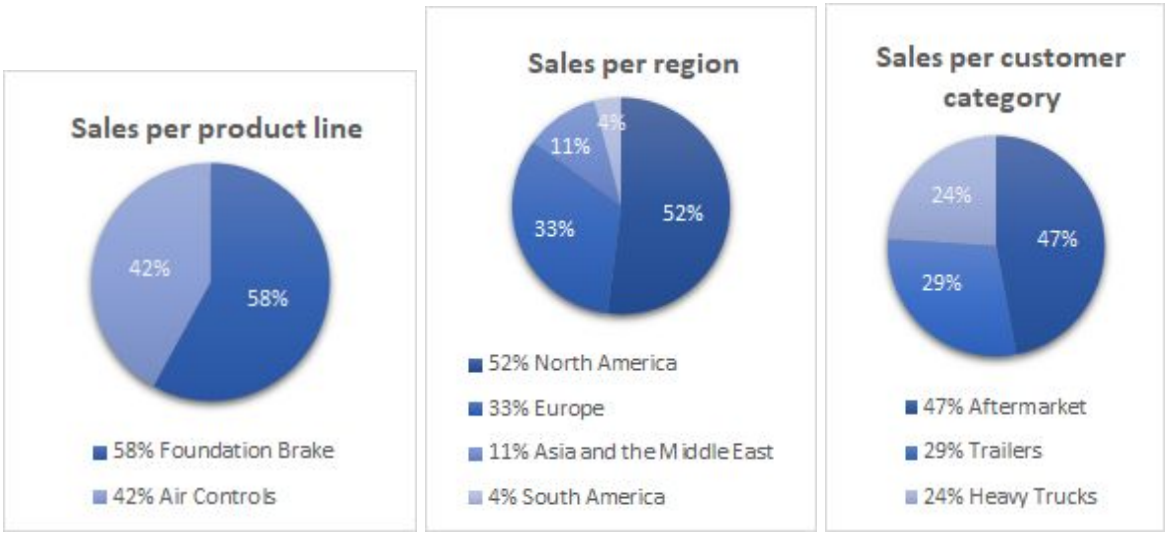

Figure 6. Business overview of Haldex (Source: Haldex Annual report 2019).

4.2 Current packaging system

For several years Haldex has used both returnable packaging and non-returnable packaging for shipping the products to their customers. At the moment, there does not exist a control system for the returnable packaging material, therefore there is a lack of management of the packaging processes flow. Haldex has several different packaging solutions for different products and customers. Haldex packaging can be divided into two segments of packaging types, the outer packaging, and the inner packaging. These two types are closer described below.

- **Outer packaging.** There are different types of outer packaging. Most outer packaging consists of lids, frames and pallets made of wood that together are formed into a complete packaging. There are different types of lids, frames, and pallets, e.g. differences in size and quality. The types include EURO-pallet, V-EMB, Haldex-pallet and Half-pallet. There are also special packaging solutions for some customers, one customer only uses a pallet and plastic as outer packaging, and one customer uses a special designed metal stand as outer packaging. For some products, cardboard boxes placed and banded on a pallet are used.

- **Inner packaging.** The inner packaging consists of inlays and wedges. The wedges are used in all brake systems to separate the brake pads. The wedges are made of plastic. Inlays is a part of packaging which is used to keep the brakes without any movement. The inlays are made of plastic and can contain four or five brakes.

Sets of the different packaging material creates one complete packaging that can handle and transport products. Regarding transportation of brakes to customers, a set is usually one pallet, some frames and one lid and a few inlays. There are always two wedges per brake. Picture 1 below shows the main packaging material, i.e. pallets, frames, lids, metal stands, inlays, and wedges, that is used at Haldex.

Picture 1. Main packaging parts.

Table 2 below shows the division between V-EMB, EURO, Haldex and Half - pallets, frames and lids which is the main packaging material that is used for the six customers that was investigated in this project. It is based on data during the period 1/1 - 31/8 -2020. It can be seen that V-EMB is the most used packaging followed by EURO packaging.

Table 2. Division between V-EMB, EURO, Haldex and Half -pallets, frames, and lids.

Package	V-EMB	EURO	Haldex	Half	One-time EURO-pallet
Pallets	47,54%	28,03%	5,34%	0,97%	18,12%
Frames	66,14%	30,78%	2,80%	0,27%	-
Lids	58,25%	34,47%	6,10%	1,19%	-

4.3 Supply chain of packaging

This thesis focuses on the following Haldex supply chain actors: customers in Europe and one customer in the Middle East. Haldex packaging supply chain consists of two main units, Haldex and the customer. An illustration of the returnable packaging supply chain at Haldex is shown in Figure 7 below while Figure 8 below illustrates the non-returnable packaging flow. The returnable packaging flow consists of the two flows, the forward supply chain from Haldex to the customer, and the reverse supply chain, from the customer to Haldex. The supply chain with non-returnable packaging only consists of a forward supply chain. The forward supply chain contains filled packaging material which means that the packaging contains products. The reverse flow contains empty packaging material. In the reverse flow, the outer packaging is filled with inner packages, i.e. the inlays and wedges are stored in pallets.

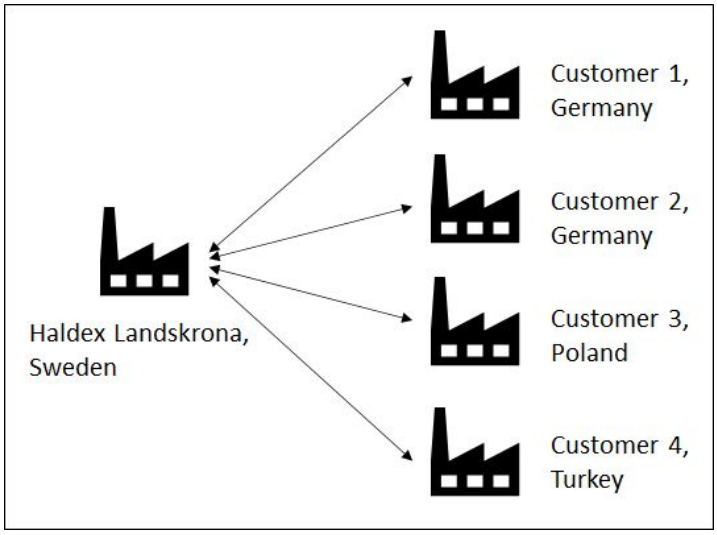

Figure 7. Flow of returnable packaging material.

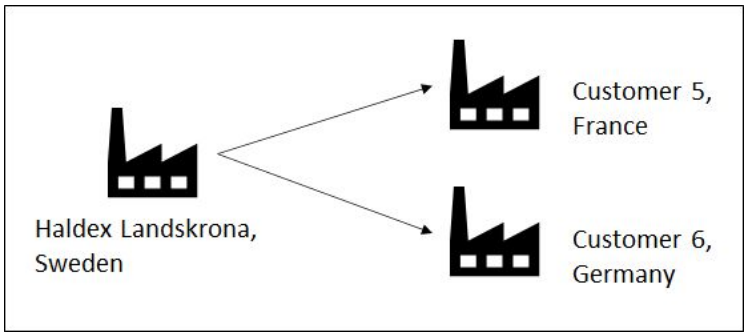

Figure 8. Flow of non-returnable packaging material.

The return packaging system at Haldex consists of both closed loop flows, i.e. *switch pool systems,* and systems with a third-party logistics company that own the pallets, frames, and lids, i.e. *systems with return logistics.* In the *switch pool system*, inlays and wedges are always included, as well as outer packaging material owned by Haldex. In the *switch pool systems,* the packaging is owned by Haldex, that has an allotment of packaging and is responsible for cleaning, maintenance, control, and storage of the packaging as well as responsible for the return flow. For one customer, named Customer 1 in the section *4.6 Customers,* the *system with return logistics* is applied, a third-party agency owns the outer packages, i.e. the pallets, frames, and lids.

4.4 The packaging material handling process

Haldex gets materials and components from suppliers, most delivered in returnable packaging from V-EMB, i.e. in a package consisting of a pallet, a lid, and frames. The flow is going through suppliers and the production unit at Haldex and then to Haldex customers.

The packaging material handling processes at Haldex begins with Haldex receives orders from the customer. To complete those orders and ship them, a certain amount of packaging material is needed. More exactly, the packaging material is used when the products reach the final station in the production line. The products are then placed in their package, that can for example be placing brake systems in the inlays which in turn is placed on a pallet with a number of frames or on the metal stands. When the preparation of orders is finished, the pallets are stored in an area for finished goods before they are loaded on the trucks for transportation to the customers. At the customers plants, the products will be stored in the warehouse and unloaded. This means that the packaging material is used by the customer for a certain time, to store the products in their warehouse. Therefore, customers can not return the packaging material immediately after receiving it. The customers will return empty packaging material when it fills a truck at a later date.

Returning the packaging material from the customers is a vital process. Some packaging material is lost and/or damaged during this process. Additionally, the company's control on the return flow is low. The loss of packaging material was estimated during this study and is presented for each customer under chapter *4.6 Customers*. The estimated loss of packaging material shows the percentage of lost material that will not be returned by the customer. Furthermore, there are additional losses of the pallets, lids, frames, inlays and wedges, which are not usable due to different reasons, such as not being functionable for the production line, the packaging material is broken or do not meet quality requirements for containing the brakes, for example risk for rust on the brakes. This means that the packaging needs to be sorted out. Overall, the reverse flow of packaging material is somehow affected by stochasticity, in quantity and time. This means that Haldex does not exactly know how much packaging material will be returned and when the packaging material will arrive at Haldex.

The packaging material is used to ship new products to the customers; therefore, it is important to avoid out-of-stock situations. If there is not enough packaging material, such as pallets, lids and frames in stock, Haldex needs to purchase new packaging material, or ship products in other packaging options than the original solution, or in the worst case, the company cannot ship the products which results in a loss of sales. Both returning packaging material from customers as well as purchasing new material has a fixed lead time, which means that it takes some days for the packaging material to arrive and be available at Haldex.

The following packaging material flow have been identified at Haldex:

- Outbound flow of packaging material used to ship products to the customers.
- Outbound flow of packaging material that has been damaged or is not usable for reuse.
- Inbound flow of returned packaging material, i.e. the empty packaging material that arrives from customers because of the retrieving operations.
- Inbound flow of new packaging material purchased from a provider.

4.5 Activities related to packaging at Haldex

4.5.1 Receiving

Haldex receives both returned packaging material from the customers as well as new packaging materials that have been purchased due to not enough packaging in stock. The delivery note that comes with the trucks with the returnable packaging material, looks different for each customer.

First, the shipping department will get information about the time of arrival of goods. The truck is unloaded using forklifts which is done by one or two forklifts drivers. The unloaded packaging material is stored in the particular storage area for the packaging material before it is transported to the production lines when it is needed there. Sometimes the forklift driver checks if the number of pallets is equal to the number stated on the delivery note, but in general no control of the amount of returned packaging material is done.

4.5.2 Control of amount packaging

There is no tracking system for the packaging material for the customers investigated in this study, despite for Customer 1 and partly for Customer 3. Stocktaking of packaging material is done once a week in order to check if the material packaging is enough for the upcoming production planning or if new packaging is needed to be purchased in order to avoid stock-out and a stop in the production. It happens that there is a lack of packages due to shrinkage in the reverse loop, especially for EURO-frames, pallets, and lids. The problem is solved by purchasing new packaging material. Over-stock of packaging from the third-party agency is sent back to the central agency.

4.5.3 Outbound flow

The outbound flow from Haldex plant consists of sending finished products to the customers. Packaging used for the outbound flow is mainly returnable packaging material, but some non-returnable packaging material is also used. When an order is finished and placed in the finished goods area, the packages are marked with a license plate (with information and barcodes). This license plate is scanned with a barcode scanner when the order is prepared for being loaded on the truck for shipment to the customer. Every order has a packaging instruction, containing the amount of packaging required for the order.

4.6 Customers

This chapter describes and presents data about the returnable and non-returnable packaging material flow for Haldex main customers. In total, data for six customers was investigated. The focus was on estimating the loss of packaging material, which was done by studying the difference between packaging material shipped and the amount returned packaging material. The amount of packaging material shipped to customers was calculated based on the number of products shipped, while the amount of returned packaging material is based on the delivery notes that comes with the truck driver. The customers security stock is not considered in the estimations.

The customers use different packages and Table 3 below shows which packaging respectively customer uses. The packaging depends on the customers' requirements and desires as well as type of products, i.e. if brakes, spare parts, or other components are shipped. The packages differ on dimensions such as width, length, and weight, see Table 4 below. All packaging material, except V-EMB, is owned by Haldex, meaning that Haldex purchases and pays for it. V-EMB is owned by Volvo Group, which means that Haldex needs to pay transaction costs for it.

Table 3. Customers packaging.

Customer	**Outer packaging**	**Inner packaging**
Customer 1 - Germany	V-EMB	Wedges + inlays for brakes
Customer 2 - Germany	EURO-pallet, frames, lids, and cardboard boxes	Wedges + inlays for brakes
Customer 3 - Poland	Metal stand	Wedges for brakes
Customer 4 - Turkey	One-time EURO-pallet	Wedges + inlays for brakes
Customer 5 - France	Haldex-pallet, frames, lids, and cardboard boxes	Wedges + inlays for brakes
Customer 6 - Germany	EURO-pallet, frames, lids, and cardboard boxes	Wedges + inlays for brakes

Table 4. Dimensions of the pallets.

Package description	**Width (mm)**	**Length (mm)**	**Weight (kilo)**
Half EURO-pallet	600	800	8
Haldex-pallet	820	1225	18,5
One-time EURO-pallet	800	1200	14,6
EURO-pallet	800	1200	22
V-EMB-pallet	815	1225	22,3

4.6.1 Customer 1 - Germany

Customer 1 is a big customer for Haldex and is located in Germany. The packaging flow mainly consists of returnable packaging, but a smaller part is also sent in non-returnable packaging, which is described in section *4.6.1.1 Customer 1 – non-returnable packaging*. The returnable packaging consists of V-EMB as packaging, i.e. the lid, frame and pallet are V-EMB. V-EMB is rented from Volvo Group, i.e. a third-party logistics is used in this case, and a transaction cost is

paid for every transaction of the packaging material that is done. A transaction cost is paid by Haldex both for the forward flow to the customer and the return flow of the packages that are sent back to Haldex. The reverse flow consists of V-EMB pallets filled with inlays and wedges owned by Haldex. The flow of V-EMB is controlled in a portal where all transactions from and to Haldex are registered.

The data were collected for 1/1 - 31/12 -2019 and 1/1 - 31/8 -2020. Only the loss of inlays and wedges were studied because all other used packaging for this customer is owned by Volvo Group. Table 5 below presents the percentage of loss of wedges and inlays for the two periods of time. As Table 5 shows, there is no loss of inlays during 2019 and a small loss during 1/1 - 31/8 -2020, but there are bigger losses of wedges. During the year 2019, the estimated loss of wedges was 17,61% and during 1/1 - 31/8 -2020 the loss was 26,10%.

Table 5. Losses of packaging material for Customer 1.

Packaging material	**Inlays**	**Wedges**
2019	None	17,61%
1/1 - 31/8 -2020	1,53%	26,10%

4.6.1.1 Customer 1 – non-returnable packaging

A small volume of the total volume of packaging material sent to Customer 1 is sent in non-returnable packages. Most of the non-returnable packages consist of a one-time EURO-pallet with a cardboard package consisting of a lid, frame, and bottom. One product is packed using the same cardboard package (lid, frame, and bottom) stacked on a EURO-pallet. Some products are also shipped in Half-pallets, frames, and lids. Different types of non-returnable packages are used because the products that are sent to Customer 1 are in turn sent to their customers.

4.6.2 Customer 2 - Germany

Customer 2 is one of the main customers for Haldex and is located in Germany. This customer uses EURO-pallets, frames, and lids. For some products, the cardboard boxes are used, those boxes are banded on a EURO-pallet, and the amount is very little (0,014%) compared to the other packages. The EURO-pallets, frames and lids are owned by Haldex. The reverse flow consists of inlays, wedges, EURO-pallets, frames and lids.

The data were collected during the period 1/1 - 21/9 -2020. Losses of all packaging material was studied, i.e. pallets, frames, lids, inlays, and wedges. Information about the reverse flow is based on the delivery notes which does not contain any information about the number of returned

wedges and inlays. This means that the loss of inlays and wedges was not possible to estimate. Table 6 below presents the percentage of loss of EURO-pallets, frames, and lids. As Table 6 shows, a lot of packages are lost. The biggest loss of packages is pallets, 52,51%, followed by frames, 36,24%, and lids, 29,41%.

Table 6. Losses of packaging material for Customer 2.

Packaging material	**EURO-pallets**	**EURO-frames**	**EURO-lids**
Percentage of loss	52,51%	36,24%	29,41%

In order to control if the delivery notes are correct, stocktaking of the returns have been done for this customer. This was done to see if the information on the delivery note matches the actual number of packages returned. The outer package, i.e. pallets, frames, and lids, were counted. Packages are frequently returned from this customer and the shrinkage of packages is also high, therefore the returns were controlled three times during this study. Two of three times, the delivery note was correct regarding the number of pallets, frames, and lids. But during one of the controls it was found that the number of returned packages, frames, and lids, was larger than what was stated on the delivery note.

4.6.3 Customer 3 - Poland

This customer is located in Poland and uses a special designed metal stand for the transportation of the brake system. Thus, the only packaging sent and returned from this customer is the metal stand and the wedges in the brakes.

The data were collected during the period 1/1 - 21/9 -2020. Losses of both the metal stands and wedges were studied, and the results are presented in Table 7 below. There are no losses of metal stands and there is a little loss of wedges, 11,86%.

Table 7. Losses of packaging material for Customer 3.

Packaging material	**Metal stand**	**Wedges**
Percentage of loss	None	11,86%

Stocktaking of the returned packages was done one time for this customer, this in order to check if the delivery note matches the actual amount of returned material. One truck with returnable packaging material was controlled and that time the delivery note matched the actual amount of packages.

Haldex has some control of the metal stands today. The on-hand stock at Haldex of the metal stands are registered in their business software system AX 12. The transactions are registered,

both how many is sent to the customer and how many is returned from the customer. But the stock value at the customer is missing as well as information about wedges.

4.6.4 Customer 4 - Turkey

Customer 4 is located in Turkey and is one of Haldex main customers. The products are shipped to this customer using a one-time EURO-pallet on which the inlays are stacked on and covered with plastic to protect the brakes. The reverse flow consists of one-time EURO-pallets with 26 inlays stacked on each pallet and boxes containing wedges.

The data were collected for 1/1 - 16/10 -2020. The loss of the one-time EURO-pallets, inlays and wedges was investigated for this customer and the results are presented in Table 8 below. Most of the one-time EURO pallets are not returned, 85,51 %. The loss of inlays is 5,78% while the loss of wedges is 35,99%. The cost of the loss of inlays is 2.25 times higher compared to wedges, which is because the cost of inlays is significantly higher (SEK 350/pc) compared to wedges (SEK 2.5/pc). It is not intended that the one-time EURO-pallet should be returned, the pallets that are returned are used to stack the inlays on.

Table 8. Losses of packaging material for Customer 4.

Packaging material	**One-time EURO-pallet**	**Inlays**	**Wedges**
Percentage of loss	85,51%	5,78%	35,99%

The amount returned packages was controlled one time during the study, this in order to check if the delivery note matches the actual amount of returned material. The packaging material that was of primary interest was inlays and wedges. The delivery notes from the truck that was controlled, matched the actual number of inlays. The wedges were difficult to control, because they are not delivered in standardized packages and the packaging contains a couple of thousand wedges. An estimation on how many wedges that were returned was done, and this upper estimation resulted in around 30% less wedges than was stated on the delivery note.

4.6.5 Customer 5 - France

Customer 5 is located in France and uses different types of packaging solutions and none of the packages is returned to Haldex. The largest part of products is shipped using Haldex-pallets, frames, lids and Half-pallets, frames, lids. For three of the products sent to this customer, a cardboard box is used which is banded on a pallet. One product is also shipped in V-EMB and the third-party logistics, Volvo Group, is responsible for the V-EMB packages.

The data were collected for 1/10-2019 - 14/10-2020. As Table 9 shows, none of the packaging material is returned to Haldex. The cardboard boxes are a one-way packaging while the

Haldex-pallets, frames, lids and Half-pallets, frames, lids are not returned because the customer uses the packages to store the products before they are sent to their customers using the same package, i.e. the Haldex-pallets, frames, lids and Half-pallets, frames, lids.

Table 9. Losses of packaging material for Customer 5.

Packaging material	**Haldex-pallets**	**Haldex-frames**	**Haldex-lids**
Percentage of loss	100%	100%	100%

4.6.6 Customer 6 - Germany

Customer 6 is located in Germany and is a small customer for Haldex. Most products are shipped in EURO- pallets, frames, and lids to this customer. One product is shipped in a cardboard package consisting of a lid, frame and bottom of cardboard that is banded on a pallet and one product is shipped in a carton box. The volume is very low and if the packaging material had been returned, it would probably be maximum one truck per year.

The data were collected for 1/10-2019 - 14/10-2020. As Table 10 shows, none of the packaging material is returned to Haldex. The EURO-pallets could theoretically be returned. Both the cardboard package (lid, frame, and bottom of cardboard) and carton box is a one-way packaging.

Table 10. Losses of packaging material for Customer 6.

Packaging material	**EURO-pallets**	**EURO-frames**	**EURO-lids**
Percentage of loss	100%	100%	100%

4.6.7 Error sources of estimation of packaging losses

There are possible error sources regarding the estimation of loss of packaging. The calculations of the reverse flow are based on the amount of returned packaging material stated on the delivery note. Due to the fact that the delivery note has not been verified when arriving at Haldex, and an error occurred when the truck from customer 2 was checked, there are probably more errors in the numbers stated on some of the delivery notes. This affects the estimation of loss of packaging material. Additionally, wedges are a relatively little and light component, therefore it can be difficult for the customers to estimate the amount they return to Haldex. As seen in Picture 2 below, the wedges are returned in a pallet.

Picture 2. Example of how it looks when wedges are returned to Haldex.

4.6.8 Systems and databases

Currently, there only exists a system for keeping track of the packaging material for Customer 1 and 3. Customer 1 uses a third-party logistic, and it is needed to report all transactions made. For Customer 3 there is also a system to keep track of all transactions made of the metal stands and the on-hand stock at Haldex can be seen in Haldex business system, AX 12. The outgoing tracking of the metal stands for Customer 3 is done with EDI, i.e. Electronic Data Interchange. When the metal stands are returned and arrive at Haldex, the amount is manually entered to AX 12. But the system for Customer 3 can be improved by seeing the stock at the customer. For the rest of the customers, there is no system for keeping track of any of the packaging material, which results in a loss of packages shown in the different tables presented under each customer. The desire is to have a control system which involves registrations of transactions, both outgoing and incoming packaging material, as well as stock values at Haldex and at customers. This in order to facilitate the planning of purchasing new material, avoid urgent purchases and debit the customer for the shrinkage of packages or require the customers to send back the amount of packaging material that the system indicates is on the customers site.

5. Analysis

This chapter presents the analysis of the packaging material flow in order to increase the control. The analysis is based on existing theory and empirical data in regard to the research questions. The recommendation is presented in chapter 6.

5.1 Structure of the analysis

Information from theory together with the data from the empirical study will be analyzed in order to find answers to the research question regarding how the flow of packaging material currently looking for the customers that have been studied and how the packaging material flow should be controlled in the future. The chapter begins with a review of the five key processes in the reverse supply chain. Then, a summary of the situation for the customers are presented and based on this, problems with the current processes are identified. In order to minimize these problems, where visibility and traceability of the processes is required to minimize one of the larger problems - shrinkage of packages, control systems are described as a solution. During the empirical study it was identified that the overall desire is to implement a complete control system in Haldex business software system AX 12. At last, proposals for improved packaging solutions for the customers are presented. The analysis is mainly based on the data from the conducted mapping of the customers usage of packaging material and the packaging handling process.

5.2 The reverse supply chain

The purpose of the reverse supply chain that has been studied is to reuse the packaging material in order to decrease purchasing costs of new packaging material. This shows that reverse supply chain impacts the company's financial performance as Larsen (2017) also mentions. The five key processes of the reverse supply chain at Haldex are analyzed and presented below.

Product acquisition: which is the first step of the reverse supply chain where the returnable packaging material is reacquired from the customers as Guide Jr & Van Wassenhove (2002) describe. The quantity of packaging that is returned from Customer 1, Customer 3 and Customer 4 is relatively stable, i.e. the amount returned packaging is almost the same each time. However, for Customer 2 the quantity of different packages can vary more from time to time and the quality of returned packages is often worse than what was sent to Customer 2. According to Guide Jr & Van Wassenhove (2002) the quality, quantity and timing has to be managed carefully for efficient returns and reuse. Table 11 below shows how many times per month packaging material is returned to Haldex (for the period that was studied in the empirical study).

Table 11. Number of times per month the returnable packaging is returned to Haldex.

	Customer1	Customer2	Customer3	Customer4	Customer5	Customer6
Number of returns/month	4.9(2019) 3.8(2020)	2.4	1	0.7	-	-

Reverse logistics: consist of dedicated shipments from the customer to Haldex, which is the fastest alternative. The trucks with the returnable packaging that was stocktaking during the empirical study, were returned from the customer filling a whole truck.

Inspection, sorting and disposition: the returnable packaging that comes to Haldex needs to be inspected in order to see if it fulfills the requirements to be able to be reused for shipments of new products to the customers. V-EMB is marked with a red tag when it is funded that it is broken and should be out sorted. The sorting of V-EMB takes place at the production lines when the packages have been emptied, surplus and broken packaging is sent to Volvo Group and packaging that is needed for packing new products is placed by the robot that handles the assembly of pallets, frames and lids. The inspection and sorting of returned EURO-packages is today done on the production lines, which is a process that should be kept there in order to minimize handling. Because the EURO-packages, such as frames and lids, are bound together and stacked on pallets. If the inspection and sorting is done before it is transported to the production line it needs to be stacked again which is time consuming. The problem with EURO packaging that is returned from Customer 2, is that some packaging does not fulfill the requirements or is broken. Furthermore, the robot cannot handle broken packages and it needs to be sorted out or be assembled manually. Packaging handling is ungainly and relatively heavy but is needed to be done. This task is also described as labor-intensive and time consuming by Guide Jr & Van Wassenhove (2002).

Recovery operations: Repairs of returned packaging that is broken is seldom done, but it happens that the metal corners of the frames are bent correctly if they are incorrectly bent and cannot be mounted on top of each other. Expect that, repairs of broken packaging only take place when there are components in the pallet that will be used in production. Then it is sometimes easier to repair broken pallets and use the contents, to avoid repacking a pallet. Other than that, no pallets or frames that are broken are repaired, i.e. broken packaging are sorted out in the previous step.

Distribution and Sales: In contrast to the reverse supply chain of products, packaging material is not remarketed and sold again. The returnable packaging material that is good enough, is used again by Haldex for shipping new products.

Haldex would benefit from having a more well-thought-out supply chain, where the forward and reverse supply chain is considered simultaneously and having the same level of management

oversight, strategy, and investments. This in order to create a more sustainable supply chain by reducing storage, shrinkage and purchasing costs. By treating the reverse supply chain like an afterthought is costly in the long run.

5.3 Summary of Customer 1-6

Packaging affects the supply chain in different aspects and interacts with logistics, manufacturing, and information systems (Chan, Chan, Choy, 2006; Pålsson, 2011). Different aspects for Customer 1-6 that were collected during the empirical study is summarized in Table 12 below. A common problem for the customers is the loss of wedges. The wedges stand for a little part of the total cost of packaging material, between 3-6% of the total cost of packaging material (for Customer 1 and Customer 4 - 6%, Customer 2- 4%, Customer 3 - 3%). The loss of packaging material can be connected to the lack of visibility which can be attained by a throughout tracking system. But as Table 12 indicates, there is not a tracking system for all customers and for all packaging material types. In the loss of packaging, there are also packages that break. The older the returnable packaging, the more the number of damaged packaging will increase.

Table 12. Summary of different aspects for Customer 1-6.

Aspects	**Customer1**	**Customer2**	**Customer3**	**Customer4**	**Customer5**	**Customer6**
Volume	High	Middle	Low	Middle	Low	Very Low
Packaging	V-EMB pallets, frames, lids	EURO-pallets, frames, lids	Metal stand	One-time EURO-pallet	Haldex-pallets, frames, lids	EURO-pallets, frames, lids
Ownership	Volvo Group	Haldex	Haldex	Haldex	Haldex	Haldex
Tracking-system	Volvo portal	None	AX 12	None	None	None
Loss of returnable packaging	High loss of wedges	High loss of pallets, frames, and lids	Small loss of wedges	High loss of wedges	Nothing is returned	Nothing is returned
Handling at production lines	Automatically by robots, works well	Automatically by robots, works well	Automatically by robots, works well	Automatically by robots, works well	Manually, robots cannot handle the frames	Automatically by robots, works well

5.4 Problems with the current process

The company does not keep track of the exact inbound and outbound flows of packaging material for all customers. Therefore, Haldex has low control on the flow of the packaging material that they own. This leads to the following consequences:

- Packaging is lost.
- Extra costs for purchasing new items.
- Difficulty predicting the flow of returned assets, which can lead to out of stock-situations.
- Returned packaging material is not controlled, neither amount nor quality.
- Risk for out of stock situations. Urgent orders can be necessary which leads to higher purchasing cost, due to urgent delivery.
- No throughout tracking system to control the forward flow and the reverse flow of packaging for most customers (except partly Customer 1 and Customer 3).

According to Kim and Glock (2014) many industries have problems with returnable packaging material, such as shrinkage and unpredictable return regarding time and quantity. This corresponds to the problems identified at Haldex and listed above. To manage these problems, visibility and a proper management approach of returnable material is needed according to Ilic et al. (2009). Some type of technology is also necessary to control the returned packages by tracking and tracing it.

5.5 How to minimize shrinkage of packaging material?

Kroon and Vrijens (1994) define three control systems to categorize the return logistics system, which are switch pool systems, systems with return logistics and systems without return logistics. The packages that Haldex own, such as inlays, wedges, EURO-packaging, Haldex-packaging, belong to switch pool systems while the V-EMB belong to systems with return logistics. According to Hellström & Johansson (2010) it is for the three control systems needed to have tracking systems to monitor and control the returnable material. Hellström & Johansson (2010) claims that losses of returnable packaging can be controlled using a tracking system in combination with that the tracking data is used correctly. Using a tracking system makes it easier to achieve a profitable reuse system. Additionally, the size of the packaging fleet can be minimized. However, it is not enough to only collect tracking data, proper actions and continuous management attention is needed to achieve savings. (Hellström & Johansson, 2010)

5.5.1 Control system

It is not possible at the moment to know where packaging material is in the system without asking every customer how much they have. The transparency upstream and downstream in the system is very poor, without this information it is difficult to plan for the packaging material. Without this documentation personnel responsible for ordering packaging material have weak data to support a purchase request.

At the moment, the packaging handling process is trust based which results in a lack of control and visualisation of the packaging flows and inventory controls also needs to be done each week at Haldex. This in combination with relatively long distribution times, results in that personnel responsible for ordering packaging material tend to compensate for this unreliability by building inventory buffers which results in increased tied-up capital. There also exist underflows at customers that use packages owned by Haldex for its customers and those flows are unknown but results in a loss of packaging material for Haldex, especially for Customer 2. The only alternative to prevent that no out of stock situations arise is to have excess of packaging material and consistently order new.

Three different systems which can be used to minimize the loss of returnable packaging material, are analyzed below. There are two different variants of control systems which are based on tracking the flow of the packaging material. One of the systems takes advantage of Haldex business software system, AX 12, and the other option uses a totally manual system consisting of a spreadsheet. The third option that is discussed is a deposit system for the packages that are owned by Haldex.

AX 12

For the customers using returnable packaging solutions, it is necessary with both visibility and a proper management approach to improve process efficiency and control of the returned material according to Ilic et al. (2009). Ilic et al. (2009) mentions that this can be achieved by having a tracking system, where all outgoing and incoming packaging material is tracked. Since there already is a tracking system implemented and working for Customer 3, the same system can be applied for the other customers. At the moment, all transactions of the metal stands for Customer 3, both from Haldex to the customer and from customer back to Haldex, are visible in AX 12 as well as the on-hand stock at Haldex. The stock at the customers site is missing in the system today. By having customers on-hand stock in the system, Haldex can easily see if the customers do not return the packaging and therefore also require the customers to send back the amount that the system shows or pay for the missing packages. In that way, the shrinkage of packaging and loss of money can decrease.

What should be done in AX 12 for Customer 3:

- Add the on-hand stock at the customer site.

What should be done in AX 12 for the other customers:

- Add on-hand stock at Haldex.
- Add on-hand stock to customers.
- All transactions should be seen, both outgoing and incoming.

The packaging material that should be tracked in AX 12 is the ones that Haldex own. This means that the following packaging should be tracked for respectively customer:

- EURO-pallets, frames, lids
- Haldex-pallets, frames, lids
- Half-pallets, frames, lids
- Inlays
- Wedges

Ilic et al. (2009) states that it is needed with a technology that delivers identification and tracking capabilities. Different technologies are available like manual systems, barcoding systems and RFID. Since RFID requires big investment costs, it is not the most relevant option. For Customer 3, the outgoing tracking of the metal stands is done with EDI - Electronic Data Interchange, i.e. information is electronically interchanged (Vrbová et al., 2018). The incoming returnable packaging material from Customer 3 is tracked manually by adding the amount of returned metal stands to AX 12. The tracking for the other customers is suggested done in the same way, i.e. the outgoing material is tracked by EDI and the incoming returned packaging is manually added to AX 12. The administration of returned packaging will take little time to do and there is also a cost to put up the suggested tracking system.

Spreadsheet

Another option is to track all outgoing and returned packaging material in a spreadsheet. It works by entering all information into a spreadsheet, which is a totally manual process. The principle for a spreadsheet system is the same as for the system in AX 12. Like in the AX 12 system, the on-hand stock at both the customers and at Haldex should be tracked in the spreadsheet which makes it possible to see if the customers do not return the packages and require them to either send back the amount that is shown in the spreadsheet or pay for the missing packages, i.e. same principle as in the AX 12 system. The advantages with this system are that no technology is needed, and costs are low, which makes it easy to implement. But the drawbacks are that a

manual system is both labour and time intensive, and there are high error rates. Another disadvantage with this system is that information is decentralized.

Deposit system

The third option to minimize the loss of money due to shrinkage of packaging material without tracking the flow of packages is to couple the switch pool system, i.e. all packages owned by Haldex, with deposits. A deposit system means that the customer pays a deposit for every package that is sent to them from Haldex. The deposit is refunded when the customer has returned the packaging material to Haldex. The advantage with this type of system is that it encourages quick returns of the packages and provides a financial incentive to return the packaging material. The deposit should be equal to the value of the package so it can be used to compensate for the loss of packages. The advantages are that the need for a tracking system is reduced which Hellström & Johansson (2010) also mentions. But the disadvantages are that there will be tariffs for Haldex when buying back the packages for customers outside the European Union. A deposit system will not only create a large flow of money but improve the sales statistics which is misleading because it is the same package that is sold and bought repeatedly.

5.5.2 Wedges

In the empirical study of the customers a recurrent problem was the loss of wedges, i.e. a lot of wedges are not returned. This can partly depend on the brakes being resold. An alternative is to sell the wedges to the customers together with the brake systems and when the customers return the wedges, the customers are repaid. Another option is to control the amount of wedges by having a tracking system for them. To minimize the error in this tracking system regarding the amount of wedges that are tracked, the amount of returned wedges can be controlled. The wedges can be controlled in following ways:

- Weight the pallet and frames together with the wedges.
- Counting the wedges manually.
- Counting the wedges based on volume, the amount of wedges will be equal to the volume of the packaging divided with the volume of one wedge.

The wedges are light and small; therefore, their weight is small compared to what a pallet with frames weighs. Option one, weighting, is difficult because pallets can differ in weight and factors as moisture affect the weight. An average value, e.g. of ten pallets filled with wedges, can be taken to decrease the impact of different weights of the pallets. Option two, counting manually, will be a very time-consuming task and is not profitable when comparing the cost of having a control person against savings due to customers overestimating the amount they return. The third

option, controlling the wedges based on volume can also be a bit difficult since how compactly packed the wedges are can vary.

Since it is a bit difficult to control the wedges, the most time effective option is to go after the delivery notes. But then one should be aware that the customers overestimate the amount of wedges that they return.

5.5.3 Delivery note

When a truck arrives at Haldex with returned packaging material, a delivery note comes along with the truck driver containing information about amount and type of packaging. The delivery notes for Customer 1, 3 and 4 contain all information about packaging that is returned back to Haldex, i.e. the amount of every packaging is stated on the delivery note. But the delivery note for Customer 2 only contains information about the amount of pallets, frames and lids that are returned to Haldex and therefore information about inlays and wedges are missing. Therefore, the customer needs to add information about the amount of inlays and wedges to the delivery note so these items can be controlled and tracked in a control system. Further, this customer needs to be more accurate when writing the number of packaging on the delivery note. Since, during the empirical study it was found that the delivery notes do not match the real amount of packaging returned in the truck. The delivery note from this customer is also filled in by hand, but it had been clearer if it were written on the computer.

In order to make sure that the actual amount returned packages matches what is stated on the delivery note, it is suggested that a couple of controls of the returns are done when implementing a tracking system. This to see if the delivery note is correct and to minimize the error in the tracking system. If the delivery note from the customers matches what they actually return, it is enough with spot-checks in the future. But if the delivery note does not match the actual amount of packaging material, it is necessary with more accurate controls.

Customer 5 and Customer 6 do not return any packaging material at the moment. If they start to return packages, it is important that they write all different packages and amount of them on the delivery note. This in order to make it possible to register the returns in a tracking system.

5.6 Packaging proposal for customers

In chapter *4.6 Customers,* data concerning the packaging flow for six customers were presented together with its assumptions and simplifications. In this section, proposals for the customers packaging solutions will be presented for further analysis. Table 13 below shows to which customers other packaging solutions will be proposed. At the moment, none of the customers that use packaging owned by Haldex are charged deposits or rents, even if they do not return the

packaging material. All customers use returnable packaging, but the returnable packaging only circulates between Haldex and Customer 1-4. Below, the analysis for each customer is presented.

Table 13. Proposed packaging solution for the customers.

Customer	Current outer packaging	Proposed packaging solution
Customer 1 - Germany	V-EMB	-
Customer 2 - Germany	EURO-pallet, frames, lids	V-EMB
Customer 3 - Poland	Metal stand	-
Customer 4 - Turkey	One-time EURO-pallet	-
Customer 5 - France	Haldex-pallet, frames, lids, Half-pallets, frames, lids	One-time Haldex-pallets / V-EMB
Customer 6 - Germany	EURO-pallet, frames, lids	One-time EURO-pallet

5.6.1 Customer 1 - Germany

This customer has a high turnover of V-EMB packaging because high volumes of brakes are sold to the customer. The packaging solution works well, in production, warehouse and handling according to interviews. Therefore, the solution should be kept. The current solution can be improved by tracking the inlays and wedges in AX 12 or in a spreadsheet.

5.6.2 Customer 2 - Germany

There are problems with large losses of packaging material for Customer 2. Two possible options are using a third-party logistics company that owns the pallets, frames and lids or implementing a throughout control system as presented under *5.3.1. Control system*. If a control system is implemented and works properly, the advantage is that there already exists a fleet of returnable packaging and no transaction costs need to be paid to a third-party logistics company. The business system, AX 12, or a spreadsheet will keep track of the stock at the customer site and by doing that the customer can be debited with the cost of lost material, i.e. they need to pay for material that they do not return back to Haldex. But in a scenario where the control system does not work and Customer 2 does not pay for the lost packaging material, a lot of money can be saved yearly by changing to V-EMB if one only considers transactions cost against cost for lost packages. The cost can be reduced by 53% annually if V-EMB are used instead of EURO packaging. This saving is based on the cost for lost packaging compared to if a transaction cost was paid, i.e. the transaction cost is 47% of the cost of lost packaging material.

The advantage with V-EMB is that no investment cost is needed compared to EURO-pallets. But on the other hand, a transaction cost for every transaction of packaging material is paid. There will not be shrinkage of pallets, frames, and lids due to the ownership of a third-party logistics. Further, if EURO-pallets, frames, and lids are replaced with V-EMB it results in less changes in the production. The production only needs to handle one type of packaging instead of two types, much less changes for the robots and fewer places inside is needed to store and place packaging. This, since Customer 1 uses V-EMB. But the EURO and V-EMB packages have different sizes. V-EMB pallets are a little bit larger than EURO-pallets. Today, inlays with 4 brakes are used. If larger pallets are used there may also be possibilities to change inlays to 5 brakes per inlays, but that requires a larger investment cost. The benefit with changing inlays is that the degree of filling per package increases.

To attain a sustainable reverse supply chain with this customer, it is needed to work more closely for efficient returns which are in line with what Guide Jr & Van Wassenhove (2002) recommend. Today there is a lack of communication. According to Hellström & Johansson (2010) continuous management attention together with proper actions are required to minimize shrinkage and attain savings.

5.6.3 Customer 3 - Poland

This customer has a special designed packaging solution, where large investment costs have been incurred and production has been adapted to the metal stand and works very well. Additionally, the return flows work properly and therefore it should be kept. One thing that can be improved regarding the whole packaging solution is to add information to AX 12. If a stock value at the customer plant is added to AX 12, visibility of the flow is increasing and Haldex can easily keep track of where the packages are.

5.6.4 Customer 4 - Turkey

Customer 4 that is placed in Turkey, utilizes a very cheap solution, with a one-time pallet (cheapest type of pallet) and plastic to cover the inlays with brakes, i.e. no frames or lids of wood is used. The distance between Haldex and customers also affects the possible packaging solution, and it has to be adapted to the distance of transportation. One thing that can be improved with the current solution is to add the inlays and wedges to a tracking system, AX 12 or a spreadsheet, and keep track of them, which increases the visibility of the flow.

5.6.5 Customer 5 - France

This customer has a warehouse and can store the products for several weeks and then distribute the products to different customers. At the moment the customer does not return any of the

Haldex- pallets, frames or lids which is not sustainable nor economically profitable for Haldex. If they had returned the packaging material that was sent to them during 1/10-2019 - 30/9-2020, i.e. for one year, it had resulted in 4 trucks with returnable packaging material. During this thesis project the Haldex-pallet was changed to a one-time Haldex-pallet to decrease the packaging costs. To decrease the packaging costs spent on this customer, the alternative is to have a return system of packaging where the customer is required to return the packages to Haldex or that the customer is charged for the packaging material costs.

Another alternative is to use V-EMB, but then a transaction cost is paid for every transaction. To compare if Haldex-pallets or V-EMB is cheapest, a comparison based on an average packaging consisting of one pallet, one lid and two frames was done. A package of V-EMB (1 pallet, 1 lid and 2 frames) cost SEK 50,16 and the price for the Haldex-package is SEK 280,31. This means that the Haldex-pallets, frames and lids need to be used at least 6 times if the Haldex-packaging solution should be cheaper than V-EMB. The size of V-EMB is the same size as Haldex-pallets, therefore a change is possible from that perspective. Further, the robots in the production lines cannot handle Haldex-frames. Therefore, the orders with Haldex-packages are running without assembling the frames automatically by robots and afterwards the frames are needed to be put on manually which is time consuming and not cost efficient. But since this customer is a warehouse, changing to V-EMB would require the customer to repack the products which increase the handling in the system and increases the cost for the customer.

Five products are sent in Half- pallets, frames, and lids. If the products are packed in a one-time Haldex- pallet instead of two Half- pallets, the cost decreases. But some orders are only sent one time per month in a Half- pallet, therefore it is not space efficient or cost efficient to change the package. The option is to send them as a packet, i.e. in a cardboard box.

5.6.6 Customer 6 - Germany

Small volumes are sent to this customer, thus little packaging material and there are no returns of the EURO-pallets, frames, and lids. Since nothing is returned it is cheaper to use a one-time EURO- pallet than today's solution with EURO-pallets. The size of the packaging is the same and production lines are not affected. This results in a decrease of cost with 16,6% annually. An even cheaper alternative is to change the EURO-packaging to one-time Haldex-pallets and Haldex- frames and lids. This change results in a decrease of cost with 20,2% annually. Additionally, it should be reviewed if cardboard boxes can be used for spare parts instead of sending them in pallets to decrease the costs a little bit more.

6. Recommendations

This chapter presents the recommendations to Haldex. The recommendations are connected to research question two.

6.1 Control system for the customers

In general, a control system with a tracking technology is necessary for managing and controlling losses of returnable packaging material and it has an economic and sustainable advantage.

The principal recommendation to Haldex regarding the packaging material flow is to implement a control system. This in order to minimize the problems with the current process, listed in section 5.4, such as loss of packaging material. A control system increases the visibility and traceability of their packaging material in both the forward supply chain and the reverse supply chain. Haldex are recommended to firstly take advantage of their business software system, AX 12 and implement a control system in AX 12 for all packages that they own, i.e. inlays, wedges, EURO-pallets, frames, lids and Haldex-pallets, frames, lids and Half-pallets, frames, lids. A control system in AX 12 is less labor and time intensive than a manual system in a spreadsheet, but it requires larger investment costs.

Since there already exists a tracking system for the metal stands for Customer 3, where all transactions that are made can be seen in AX 12 as well as the on-hand stock at Haldex, the same system can be applied for the other customers and also adding the on-hand stock to customers. So, in AX 12 the on-hand stock at Haldex and the on-hand stock at the customer site should be tracked. This makes it possible to see where in the flow a package is. This system will not only decrease shrinkage of packages and purchasing cost, but also facilitate the inventory management of packages at Haldex by no need to over-ordering and building inventory buffets that results in increased tied-up capital. By having the customers on-hand stock in AX 12, Haldex can easily see if the customers do not return the packaging and therefore also require the customers to send back the amount that the system shows or pay for the missing packages. This control system creates a more sustainable supply chain, by decreasing the shrinkage of packaging and loss of money.

The packaging material is recommended to be tracked in the same way as the metal stands for Customer 3 is done. This means that all outgoing packages are tracked in AX 12 automatically with EDI and the incoming packages are manually entered to AX 12 by the shipping department or by the incoming goods department.

Further, the tracking of the returned packaging material from the customers is dependent on the data on the delivery notes that comes with the truck drivers. Therefore, it is recommended to

increase the quality of the data on delivery notes. It is of importance that these are correctly written, regarding both type of package and amount. Today, there are a lot of data gaps, especially for Customer 2. It is recommended to do spot checks in order to control if the delivery notes match the actual amount of packaging that is returned.

Lastly, Customer 5 and 6 do not return any of the packaging material. Therefore, it is recommended to have a deposit system for these customers, which means that they should pay for the returnable packaging material that is sent to them. If they start returning it, Haldex should consider switching to a tracking system.

7. Conclusion

In this last chapter the conclusion of this master thesis is presented. Firstly, the research questions are answered. Afterwards possible future research fields are suggested. Lastly, contribution to theory is discussed.

7.1 RQ1 - *How is the usage of the packaging material flow currently looking?*

The current packaging material flow at Haldex was investigated using both qualitative and quantitative data available from company databases and delivery notes and by interviewing people that work with the packaging material flow at Haldex. This was done to attain deeper insights into the challenges of the current packaging material flow mentioned in section 4. The analysis revealed that there are large losses of wedges for all customers and big losses of EURO-packaging for Customer 2. There are no implemented control systems for tracking the material flow and to detect these losses of packaging material. This results in an economic loss. The losses in the current flow of packaging material is shown in Table 14 below.

Table 14. Usage of packaging material.

Customer	**Packaging**	**Ownership**	**Losses**
Customer1	V-EMB pallets, frames, lids Inlays, wedges	Volvo Group (only V-EMB) Haldex	Wedges - 17,61 % (2019) Inlays - none (2019) Wedges - 26,10% (2020) Inlays - 1,53% (2020)
Customer2	EURO-pallets, frames, lids, inlays, wedges	Haldex	Pallets - 52,51% Frames - 36,24% Lids - 29,41%
Customer3	Metal stand, wedges	Haldex	Wedges - 11,86%
Customer4	One-time EURO-pallet, inlays, wedges	Haldex	Wedges - 35,99% Inlays - 5,78%
Customer5	Haldex-pallets, frames, lids	Haldex	Nothing is returned
Customer6	EURO-pallets, frames, lids	Haldex	Nothing is returned

7.2 RQ2 - *How should Haldex control the packaging material flow in the future?*

Haldex is recommended to implement a control system in their business software system, AX 12, by tracking all outgoing and incoming returned packaging material that is owned by Haldex. By tracking both the on-hand stock at Haldex and the on-hand stock at customer for each package, one can see where a package is. Thus, if the customers do not return the packaging it can easily be seen in AX 12 and Haldex then have the possibility to require the customers to send back the number that is shown in the system or pay for the missing packages. The control system increases the visibility and traceability of the packaging flow which helps to decrease losses of packaging and therefore decrease purchasing costs of new material, which in the end creates a more sustainable supply chain. For the customers that do not return any packaging material, it is recommended to sell the packaging, i.e. having a deposit system for these customers, which means that they should pay for the returnable packaging material that is sent to them. If they return the packages Haldex refund the deposit.

7.3 Future research

Haldex volumes of the disc brakes are increasing in the coming years and material flows are becoming more complex due to subcontracting of some parts. Therefore, it would be interesting to do a similar study in a couple of years to see how these changes have influenced the packaging material flow and handling process. New technologies and regulations for packaging systems and control systems can as well be studied. It would also be interesting to follow up the implementation of the control and tracking system, to evaluate and improve it.

Further, it had been interesting to do a comparison with a similar company, i.e. a company that owns their packaging material and has customers in Europe. The objective with the research would be to study how they control the flow, which system they use and how it is working. To study which differences there are and find success factors.

7.4 Contribution to theory

The reverse supply chain has during the last years got a lot of attention. Most of the studied literature focus on the reverse supply chain of products, i.e. reacquiring the used products from customers, reworking them and at last remarketing them, while the literature of the reverse supply chain that manage packaging material are limited. This thesis has analyzed control and tracking systems to increase visibility and traceability of the returnable packaging material handling process. Hence, the study makes a minor contribution to theory by developing the area of control system of returnable packaging material. The study adds to the empirical information

like shrinkage of returnable packaging material and problems with it when there is not a thorough control of packaging material.

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Appendix A

Interviews

The questions are divided into different categories. These questions were asked to different people that are responsible and involved in the different subjects at Haldex.

Packaging material

- What packaging is used for each customer?
- What costs are associated with each package?
- Which packaging is owned by Haldex and which is rented?
- Which packaging works well?
- Which packaging works less well?
- How does the handling of the packaging work?
- How is bad packaging sorted out?
- What are the problems with the packaging handling system?
- Which customers send back the returnable packaging material?
- How and when is the packaging material inspected, repaired, and sorted out?

Production

- Are there any problems with the packaging handling at the production lines?
- Advantages and disadvantages with V-EMB, EURO-packaging, Haldex-packaging, metal stands?
- How is the inspection and repairs of packages handled?

Warehousing

- How is the handling of the packages that is going to be send to the customers?
- How is the handling of the returned packaging material working?

Packaging control systems

- How is the returned packaging material handled?
- Is the returned packaging material controlled regarding quantity and quality?
- Is there any control system or tracking system for the packaging material?
- What problems is there with the current packaging management system?
- What is tracked in AX 12 today?
- How are the metal stands registered in AX 12 today? (manually or automated)