Case study at Scania: how packaging options affect supply chain operations and costs

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Preface

This master thesis represents the last part of our education in Logistic and and Supply Chain Management at the Faculty of Engineering, Lund University. The thesis corresponds to 30 ECTS credits and was written during the spring of 2018. The assignment was initiated by Scania AB, Södertälje and conducted in collaboration with the Division of Packaging Logistics at the Department of Design Sciences, Faculty of Engineering, Lund University. In these twenty weeks we have studied a lot about the returnable packaging operations and its supportive functions at a large company as Scania. We realized how Scania has the power and influence among international market, Swedish companies but at the same time understood that changes in business create difficulties of executing them.

We would like to thank Scania, especially our supervisor at Scania, Tom Varis, for his support and valuable inputs to write this thesis in a world leading manufacturing company in the automotive industry. It has been both exciting and study effective. In addition, we are thankful to all employees in Scania who spend time on our project providing relevant information and showing current logistics operations. We express our gratitude to company Vida which also make great contribution to our thesis. We would also like to thank Henrik Pålsson, our supervisor at Division of Packaging Logistics, for his time, helpful recommendations and guidance throughout this Master thesis project.

We wish Scania all the best in optimizing the packaging system and hope that this master thesis will be valuable help in the further work.

Abstract

Background/introduction: Scania supply chain is responsible for packaging to protect parts during transportation from their suppliers around the world. For many years Scania has used returnable packaging for inbound logistics of automotive parts. Scania packaging can be divided into two groups; namely Standard packaging and Special packaging.

Problem description: When introducing a newer solution to the packaging system the total costs that will be incurred in the supply chain is unknown. Currently the costs related to the tooling and purchasing are available. However, other costs such as handling cost, packaging material cost, transportation cost, assortment cost and warehousing of empty returnable package costs are not available at a common point. This makes it difficult for the packaging department to estimate the total cost of the packaging in the supply chain when increasing or decreasing the size of the available packaging assortment.

Purpose: The purpose of this project is to identify cost drivers of packaging in the supply chain and then eventually determining how the size of the packaging assortment affects total packaging-related costs in the supply chain loop at Scania.

Research objectives:

- What type of costs in the supply chain will be affected if the size of the packaging assortment is changed.
- How does packaging influence on overall supply chain cost in transportation, warehousing and material handling.
- Who are the most affected actors and activities in the supply chain if the size of the packaging assortment is increased or decreased.
- Which are the characteristics of packaging assortment that will impact the costs in the supply chain.

Methodology: A case study research method with using both qualitative and quantitative data is adopted. This data is then utilized to calculate the total packaging supply chain cost with activity based costing method and eventually finding the most impacted cost drivers in the packaging supply chain.

Conclusion/findings: It was noted that changes in packaging influence more on transportation costs and on costs for renting additional space at storage. The highest costs will be at breakdown as they use much manual work and its turnover is high as well. Scenarios showed that there is an opportunity for potential optimization in logistics and packaging, new spacers with better fill rate capability for new part can save spending’s and reduce emissions.

Keywords: Supply chain, returnable packaging, Activity based costing, process mapping, packaging material.

Executive Summary

Introduction

Competition is high and industries have started to focus more on total logistics costs as well as on environment aspects with a focus on decreasing pollution and fulfilling government requirements. Scania is a manufacturer of commercial trucks, buses and provides transport solutions. It is a global company which operates all over the world and has its headquarters in Södertälje, Sweden.

It has a supply chain network of parts supplied to production sites and meets demand from different business units. Scania supply chain is responsible for packaging to protect parts during transportation from their suppliers around the world. Packaging affects logistics activities such as transportation, warehousing, handling, facility location among others and contributes significantly to the entire cost of the supply chain, meaning that packaging drives cost in the supply chain. Scania (Södertälje) is currently using a returnable packaging system for sourcing most of its parts from suppliers.

New demands from the production and logistics systems require a review of the current returnable packaging system to be able to find out the overall impact of packaging on total logistics costs and on supply chain actors. Currently Scania's packaging department lacks the holistic view of the packaging impact on the supply chain activities, this indicates that when a change in size of the packaging assortment occurs the packaging department is unaware of the most impactable drivers in the supply chain, the total cost of packaging and all affected supply chain actors.

Objectives

This project focuses on determining how the size of the packaging assortment affects total packaging-related costs in the supply chain loop at Scania and subsequently identifying the impactable drivers to support the current and future projects aimed at developing a new returnable packaging assortment.

To fulfil the purpose of this project the following questions were answered:

- ➔ What type of costs in the supply chain will be affected if the size of the packaging assortment is changed
- ➔ How does packaging influence on overall supply chain cost in transportation, warehousing and material handling.
- ➔ Who are the most affected actors and activities in the supply chain if the size of the packaging assortment is increased or decreased.
- ➔ Which are the characteristics of packaging assortment that will impact the costs in the supply chain.

Methods

Thesis focused on one case study company, Scania. Combination of different methods were used to fulfil the general purpose of the thesis.

The project was built on quantitative and qualitative methods to give a broad understanding of the packaging system situation and calculation models at Scania.

Such methods as interview, observation, survey and documentation were applied to get data needed for building empirics and creating base for costs analysis.

Results and discussion

The outcome of this research gives a better understanding of the packaging process throughout the supply chain. It shows that packaging affects costs and any changes in its assortment leads to costs increasing or reducing.

Project results express that filling more products into packaging save space in storage and transportation cost. Both sites have high spending and even a small increasing of efficiency gives reduction of costs. Implementing of new packaging with better fill rate requires time and money for its development but in the future it will give an outcome of costs reduction.

Thesis also showed the benefits of introduction plastic pallets where they give savings in transportation because of total weight reduction. Today Scania does not have full volume load into trucks as there is weight limitations and plastic pallets will help this problem and it will be possible to load more parts in one truck.

Conclusions

To estimate packaging cost system, Activity based costing method was used where identified activities were matched with resources for completing those activities. Resources were translated to costs and grouped per activity and per type of packaging. Using this method, it was quite clear to understand where spending is higher or lower. Such a method opened up opportunities to see how changes in the packaging system influence supply chain and its costs. Different packaging options have effects on resources needed to handle returnable packages.

It was noted that changes in packaging influence more on transportation costs and on costs for renting additional space at storage. The highest costs will be at breakdown as they use much manual work and its turnover is high as well. Scenarios showed that there is an opportunity for potential optimization in logistics and packaging, new spacers with better fill rate capability for new part can save spending’s and reduce emissions

Output of changes in costs are provided by the excel tool (which gathers results from ABC) and allowing adapting resources to a new packaging assortment. Output of changes in costs are provided by the excel tool (which gathers results from ABC) and allowing adapting resources to a new packaging assortment.

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1 Introduction

1.1 Project background

Scania is a manufacturer of commercial trucks, buses and provides transport solutions. It is a global company which operates all over the world and has its headquarters in Södertälje, Sweden.

It has a supply chain network of parts supplied to production sites and meets demand from different business units. Scania supply chain is responsible for packaging to protect parts during transportation from their suppliers around the world. Competition is high and industries have started to focus more on total logistics costs as well as on environment aspects with a focus on decreasing pollution and fulfilling government requirements.

1.2 Problem discussion

Package is the interface between the product and logistics (Hellström and Olsson, 2017). Saghir (2004) explains packaging affects logistics activities such as transportation, warehousing, handling, facility location among others and contributes significantly to the entire cost of the supply chain, meaning that packaging drives cost in the supply chain. Scania (Södertälje) is currently using a returnable packaging system for sourcing most of its parts from suppliers.

Kroon and Vrijens (1994) argues that returnable packaging system has greater influence on supply chain processes than one way packaging. Such activities as warehousing, transportation, administrative and material handling are responsible for both flows as with filled and empty packaging what makes operations more complex. The costs that are affected for these processes are:

- For warehousing it is storage space, storing equipment (racks, handling etc.).
- Fill rate
- Packaging weight
- Loading and unloading time
- Reverse transportation of empty packages back to suppliers
- Administration will be affected by packaging variants, number of packages, number of actors among others

- Material handling costs that will be affected include sorting, kitting, repacking operations.

All these interactions between the supply chain actors means that the impact of packaging on the entire supply chain is complex and finding the total cost of the packaging in the supply chain is difficult. New demands from the production and logistics systems require a review of the current returnable packaging system to be able to find out the overall impact of packaging on total logistics costs and on supply chain actors. Currently Scania's packaging department lacks the holistic view of the packaging impact on the supply chain activities, this indicates that when a change in size of the packaging assortment occurs the packaging department is unaware of the most impactable drivers in the supply chain, the total cost of packaging and all affected supply chain actors.

The information or data that is needed to find out the costs related to returnable packaging is distributed within the different functions of the supply chain which includes purchasing department, production units, packaging development and supply chain network departments. Finding the total cost of the packaging with respect to these departments will be more context specific. However, the total cost analysis will focus on the total cost of packaging in the entire supply chain. The next step will be identifying the most impactable cost drivers based on the total cost analysis method. These cost drivers are the ones that will be identified across the entire supply chain rather than the context specific for each department.

Currently the costs related to the tooling and purchasing are available. However, other costs such as handling cost, packaging material cost, transportation cost, assortment cost and warehousing of empty returnable package costs are not available at a common point. This makes it difficult for the packaging department to estimate the total cost of the packaging in the supply chain when increasing or decreasing the size of the available packaging assortment.

This project mainly focuses on finding these costs and subsequently identifying the impactable drivers to support the current and future projects aimed at developing a new returnable packaging assortment.

Summarized, a tool to calculate the cost of packaging or impact of packaging in the entire supply chain (from supplier to production hub to breakdown unit to packaging pool which is a loop within the value chain) is needed.

Literature recognizes that packaging plays an important role in any supply chain and correct packaging decisions lead to costs and emission reduction. Especially Claire Early et al. notes that a packaging design affects downstream TMS costs (e.g., logistics, inventory, and waste management), but there existed no systematic way of passing that information back upstream (across several company divisions) to the packaging designers, where the costs are most easily addressed. Lai et al. (2008) use cost and environmental impact to investigate role of packaging in its life cycle. They applied such methods as Eco-99 and life cycle assessment to define how packaging affects material flow.

Literature study in this thesis will help to find suitable methods to answer the research questions and create a base for future studies.

1.3 Purpose and research questions

The purpose of this project is to identify cost drivers of packaging in the supply chain and then eventually determining how the size of the packaging assortment affects total packaging-related costs

in the supply chain loop at Scania. The total costs include packaging material costs and all the other supply chain costs which are related to packaging through the supply chain until the supplier site.

In order to create a platform to fulfil the purpose defined above the following questions needs to be answered:

- ➔ What type of costs in the supply chain will be affected if the size of the packaging assortment is changed
- ➔ How does packaging influence on overall supply chain cost in transportation, warehousing and material handling.
- ➔ Who are the most affected actors and activities in the supply chain if the size of the packaging assortment is increased or decreased.
- ➔ Which are the characteristics of packaging assortment that will impact the costs in the supply chain.

1.4 Project scope

The scope of the project emphasizes returnable packaging in inbound logistics to production units and reverse flow of empty packages back to suppliers' site. The thesis will focus only on returnable packaging flows of the current assortment as well as introducing new ones. Costs will be calculated only for a limited number of packaging due to time limitations. Focus packaging are chosen considering the full assortment and will represent each main type of packaging such as box and pallet. This project includes investigation of the packaging flow from suppliers, production unit Chassis Assembly and three warehouses which are responsible for storing, washing and disassembling packaging to materials. Most of the project will be based on data gathered in Södertälje, Sweden, where core Scania objects are placed and also at suppliers site.

2 Methodology

This chapter represents available methods and approaches for this thesis. It explains to the reader the chosen methodology and the reasons for picking this methodology. This is followed by a discussion of the different types of data collection. Furthermore, the section also discusses the quality of this research and finally the conducted research methods will be carefully described.

2.1 Case study research

It was decided to do a case study research because of the Scania proposal. The company has a quite wide supply chain and due to the complexity of working with suppliers and other stakeholders where a case study addresses understanding the characteristics and functions of the case in all its complex phenomena. It will help to gain insight in industrial processes in the company and the research questions requires a deep understanding of real life context at Scania.

Case study - is the study where strategy includes empirical investigation of contemporary phenomenon with real life context or historical events based on multiple sources of evidence. Yin (2003) highlights the importance of context, adding that, within a case study, the limitation of phenomenon being studied and its content are usually not clearly defined. Through these studies accurate and testable theory is developed (Eisenhardt KM, Graebner ME 2007). One more reason why the case study was chosen to work on is because it does not have any special methods for the collection or analysis of the data compared with other methods. A case study is particularistic meaning that it focuses on a distinct situation, event or object. The case can express anything that is key to the phenomenon and explain it. Case study fits this thesis due to the nature of the object and that Scania is an industry company which varies through years.

There are other research methods which are considered useful in research studies. (Höst, et al., 2009).

Survey - in most of the cases it is used to answer questions such as who, what, where, how much. It is popular as it allows collecting a wide range of data from a population without any big costs. This method is not suitable because there is a need to get exact information about the company and its processes.

Archival research relates to study where historical documents are used as the principle source of data. (Bryman 1989). Applying archival research, it becomes possible to answer questions about the past and changes over time. This method deals with historical data and its analysis. The purpose of the work is to investigate a current situation and understand dependency which exist nowadays and is thus not suitable.

Concluding all the above, using case study it will be possible to draw a conclusion on empirical data, literature support and data analysis.

2.2 Strategy type of methodology

Knowledge within an area define the limitations of what nature of research that is suitable.

According to Saunders, et al. (2016) and Höst, et al (2009) there are a lot of different types of methodologies which can be applied depending on the purpose defined before. Four groups of methodology are highlighted based on study's objective:

- Exploratory - designed to identify current situation, understand what is happening and gain insight. It is very useful to recognize the problem if it has an unclear nature.
- Descriptive - describes characteristics of how something works or phenomena being studied. It usually creates the picture and the descriptions of objectives but does not answer the question how, when or why.
- Explanatory - the purpose of this study is to explain the relationship between variables, reasons or some problem and answer the questions why does it work and how?
- Problem-solving - aimed at finding solutions to problems which were identified before.

Research purpose	Question type	Suitable research strategies
Exploratory - develop pertinent hypotheses and propositions for further inquiry	what	survey, archival analysis, case studies, histories, experiments
Predictive - describe the incidence or prevalence of a phenomenon or predict outcomes	who, where, how many, how much	survey, archival analysis
Explanatory - establish cause-effect relationships	how, why	case studies, histories, experiments

Table 1 Relevant research strategies for different situations (Yin, 2009)

Research methods: case, survey and etc. Saunders, et al. (2016) and Yin (2003), Lekvall and Wahlbin (1993), case study - (Bell, 2003).

Baxter & Jack (2008) mentioned, a case study is the most suitable when trying to answer questions like "how", "why" and "in which way" which have the same nature as in this thesis.

Table 1 presents types of methodologies and how they are related to research strategies with question types. Overall, considering the research questions of this project and its purpose, it can be concluded that the most suitable strategy type is explanatory.

2.3 Approach methods (inductive, deductive)

The main purpose of reading literature depends on the approach used in research. Kotzab, Seuring, Muller, and Reiner (2006) clarify inductive approach as understanding and explaining a phenomenon. This approach more common for complex and dynamic systems. This approach often starts with data collection where it mainly consists of field visits in order to observe phenomenon in its own terms (Hirschman 1986). The approach used in this thesis is inductive where data are gathered by different methods as interviewees, observations and internal documents to get empirical studies where theoretical conclusions are based on them. The project has been started with reading great number of presentations for deep understanding area of investigation. Moreover, field observations were conducted in order to define the design of packaging flow. Quantitative data will be aimed to perform as basic for packaging cost model. The output of the model should be developed empirics and then related with the literature. Golicic et al. 2005 notes that a substantive theory is built based on the data collected.

In some research projects a deductive approach is applied where a theoretical or conceptual framework is developed and afterwards (using data) should be tested. The goal is to predict a phenomenon and research process starts with a thorough literature review and creation conceptual framework that defines variables and the dependency between them.

2.4 Quantitative and qualitative study

When it comes to problem description and research questions, it can be said that the results should have quantitative nature. Quantitative studies are based on information that can be measured or evaluated numerically (Björklund & Paulsson, 2003).

Conclusions and recommendations have been built on data which are performed in numbers for easy. Number are needed to show costs related to packaging and create cost model. In addition cost calculations are based on measured time of operations. Description of all activities and problem background will be made through qualitative studies. Quantitative research allows one to compare and analyse data quickly with high performance and the findings can be matched easily (Denscombe, 2007, p.264).

Anyway, there is also a need to explore the current processes of Scania to understand and define constraints of investigation. All processes are not described easily by quantitative studies, and this kind of study contributes to limitations of generation new possible knowledge.

Qualitative studies are applied to build a deep understanding of a specific topic, event or situation, although the chances of generalisation are lower than for quantitative studies. Qualitative approach gives the opportunity to provide details and allows having alternative explanations.

Interviews and observations are more relevant for qualitative studies whereas mathematical models and surveys are better for quantitative studies (Holme & Solvang, 1997)., Creswell (2009).

2.5 Data collection

Different methods for data collection can be the most common depending on the nature of the problem. In this master thesis several methods of data collection have been used such as interviews,

observations, documents and survey. Literature notes that the most appreciated methods are interviews, literature, observation and surveys. All of them have their strengths and weaknesses, so it becomes important to consider what type of data is needed. Data can be categorized into three groups: primary, secondary and tertiary (Booth, et al., 2008). Primary data is original information on which other research is based. That kind of data has not previously been analysed. Secondary data refers to data which has been already processed and interpreted. Tertiary are less detailed and summarized or condensed information from primary and secondary sources.

2.5.1 Interviews

In this case study, interviews play an important role in gathering relevant data. Interview can be defined as a systematic hearing of a person that could be done face-to-face or by telephone. Interview has proved itself to be cable of collecting valid and reliable data.

There has been a careful selection of people for interviewing as face-to-face meeting takes a lot of time including scheduling and preparation. Interviews has been conducted in both the internal Scania environment and outside as well. Key actors have been interviewed from different departments that are involved in the packaging flow. They are packaging engineers, logistics developers and managers of logistics processes which have experience and the right knowledge in our focus area.

Most of the interviews are conducted as a personal meeting, a face to face meeting. However, they can also be done through telephone or email as well. Saunders, et al. (2016), specifies interviews in three main categories.

Structured interview is based on questionnaires where questions are standardized or identical. They have to be carefully prepared and interviewer reads out the questions that are written. This type of interview is usually aimed to gather quantitative data. Structured interviews have been conducted during master thesis and they have been aimed to get exact data about logistics operations.

The interviews usually takes around an hour. After interviews the notes from papers have been typed in electronic form and saved to create the framework for this report. Most of the interviews have been semi-structured type where questions were predetermined and approximate agenda for the meeting has been sent to the respondents so they could have prepare for the questions that questions would be asked. Semi-structured interview is based on questions on the topics that are predetermined before and questions are composed but their order is not defined. Additional questions can be generated during an interview or some predefined questions may be excluded depending on the context of conversation.

Unstructured interviews were conducted in the operations with teamleaders and blue collar workers to get depth understanding of actions regarding packaging. In addition, there has been opportunity to ask teamleaders to provide us quantitative data as they track everyday operations. Due to the remoteness of internal stakeholders and suppliers, telephone interviews also were held. However, that kind of interviews have had disadvantages, especially when it is impossible to show respondents various layouts or maps, and ask questions based on them.

Unstructured interview is also called in-depth interviews and there is no predetermined list of questions and it looks more like a normal conversation. The interviewer has to know the approximate topic of discussion and let the interviewee talk freely.

2.5.2 Survey

A questionnaire has been used to gather information from Scania's suppliers which are mostly located in Sweden and other parts of Europe. This method has been suitable because of lack of opportunity to travel long distances. The questionnaire was sent 850 suppliers with 26% response rate.

Surveys consist of a gathering opinions and views with a wide range of people. Questions are usually prepared and are standardized. Possible answers can be rated on a scale of 1 to 10 and as well as yes/no options and sometimes descriptive answers can be presented too. These kind of questionnaires are sent by email, regular mail, etc. Comparing with interview, there is a risk of misinterpretation.

2.5.3 Observations

In this research, observations have been made to gather data about returnable packaging units. Especially how it looks like, how it is handled, stored, folded and broken down. Observations have also been very helpful to see what resources and infrastructure are used to support all activities associated with packaging. In those observations, participants have been involved and questions to employees were asked. Time for executing operations were measured and resources were counted.

Observation is a method which can be applied in different ways. Saunders et al. (2016) note two main methods:

- Structured observation with quantitative approach which is used more in descriptive studies.
- Qualitative where a participant is involved in observations and where it plays a very important role.

Structured observations are systematic and their structure should be predefined. The aim is to compare different scenarios to their structure by analyzing the collected quantitative data (Lewis, Thornhill & Saunders, 2016, p.293).

The participating observations (person or action) are used to observe the event or activities from the outside as well, so-called full observation. There are a lot of tools that can be applied by participant such as timers, meters, etc.

2.5.4 Documentation

Main documentation sources have been presentations which were found in internal company database. They include quantitative data and qualitative as well. Presentations show description of key processes, its characteristics and stakeholders. Presentation documents also helped to get a rough understanding of packaging system in Scania.

Documents include different types of written sources such as letters, emails, agendas, announcements, reports, presentations and pictures. This kind of information is ideal to be used in every case study Yin (2009). Data gathered by documentation is secondary and not always accurate. It can be tendentious and should be used with care. Data from documents can be both quantitative as well as qualitative (Denscombe, 2007, p.212).

2.6 Credibility

It is important for any research study to obtain validation, reliability and objectivity. These three dimensions should be considered when evaluating the credibility of a study. The credibility of the research is important to reduce the possibility of getting inaccurate data as the correct answers are unknown (Lewis, Thornhill & Saunders, 2016, p.149; Miller, Strang & Miller, 2010, p.11). The credibility of any study depends on the reliability and the validity as well, which is presented in figure 1. When reliability and validity are high, the credibility is also performing highly. The framework of research credibility will be explained in the following sections, such as internal validity, external validity and reliability.

Figure 1 Credibility in terms of reliability and validity (Zikmund, 2000, p.284)

2.6.1 Reliability

Ellram (1996) notes that a study can be considered reliable when it is repeatable i.e. when a replication can be possible and the same results can be reached. Reliability relates to the extent in which data collection methods are used to get decent findings (Saunders et al., 2016).

Regarding reliability in this master thesis it has been further checked manually and the results of data gathering produced the same numbers during different days and other places.

In order to increase the reliability, such as interviewing several respondents for being ensured of conclusions and applying multiple methods, like interviews and observations. Moreover, observations, documentation and interviews have been carefully selected to generate high quality of results.

Objective data has been collected from various departments and workers to be ensured that reliability is high. Moreover, statistics about packaging turnover have been extracted from several databases and outcome showed that deviation is close to minimum.

Semi-structured and unstructured interviews have been conducted more than one time with key respondents and they have provided additional deep information with conformation of notes from previous meetings. To reduce misleading during interviews, both authors attended all meetings and also had discussions after interviews to agree on all received information.

Robson (2002) mentions than there are four possible threats to reliability. The first issue is associated with participant error when data collection takes place at an incorrect time. It is explained in

an example where results of a questionnaire differ on Monday morning and Friday afternoon due to the human factor of employees who have various concentration and motivations. The second threat is subject or participant bias. It means that interviewees provides wrong information on purpose. It happens where an authoritarian management style is present or when there is a threat of employment insecurity. To mitigate that risks it is suggested to provide anonymity of respondents to questionnaires. Third, there is a risk of observer's error when researcher asks misleading questions and respondents do not understand them properly. Finally, there is also issue called observer bias when researcher interprets answers in a different way than they were meant.

2.6.2 Construct validity

When talking about comparison between case study and other research methods, the main difference is that case study focuses on investigation a phenomenon in a specific context, rather than independent of a context. (Gibbert, Ruigrok & Wicki 2008, p. 1466). Data collected for a specific case study cannot be easily replicated which makes it important that the right measures are identified for the concepts being studied (Yin, 2009).

Construct validity is determined by the traditional meaning of validity. Validity is concerned with whether the results are really about what they appear to be about.

In this master thesis multiple sources of evidence have been used as interviews, observations and internal documents. Internal documents helped to validate data from other methods of data collection.

The validity plays an important role in a case study in order not to move away from the study objective. To reach an objective, there are a lot of approaches and when only one is used, various assumptions can appear. When methods are mixed and enabled, it can be likened to triangulation. Triangulation is a very effective approach to apply in case studies because there can be combinations of interviews, observations and documents (Lewis, Thornhill & Saunders, 2016, p.139).

2.6.3 Internal validity

Internal validity relates to a casual conclusion or cause-effect relationships based on a study result, which is defined by the level to which a research reduces systematic error. The aim is to visualize all perspectives of the research. Sometimes results are not arranged with the expectations and they have to be described intensively to increase validity.

To get the internal validity in this master thesis, semi-structured interviews with open-ended questions have been applied in order to minimize the risk of the interviewees being misled in their answers.

Some of interviews have been recorded not to miss any exact information and to show written resources to respondents. Respondents have been checked on how their answer were understood and interpreted.

Actions such as explanation building, addressing rival explanations and using of logic models help to increase validity (Yin, 2003). Anyway, internal validity test is only suitable for a causal or explanatory case study. Though it can be applied for descriptive or exploratory studies.

2.6.4 External validity

External validity is related to the degree of the generalization of the research findings to other situations. It means the results from one case company can be applied to other areas that are beyond the research. Different aspects such as random sampling, proper sample size and adequate response rate should be considered.

For this master thesis, the studied phenomenon is only investigated in one supply chain. External validity has been used in this project for generalization of results from investigation at suppliers sites. The sample size of observations is only four suppliers due to the time and geographical constraints. That sample size has been based on various criteria in order to generalize information about all Scania's suppliers.

Premature conclusions has not happened in part due to deep discussions between authors and Scania supervisor. The risk of biased results has been reduced by careful selection of interviewees with different work experience, background and management level.

Yin (2009) suggests the practice of analytical generalization for case studies where results are compared with existing theory.

3 Theoretical framework

This thesis focuses on understanding the packaging system of the supply chain, where costs play a key role as an indicator of performance. In order to study practical issues, theoretical framework will provide the concepts and definitions of Supply chain management (SCM), packaging logistics, processes and costs.

3.1 Supply Chain Management

This section defines and describes the concept of supply chain and supply chain management to figure out the role of Supply Chain (SC) in industrial companies and what common SC has to do with flows.

3.1.1 Definition of Supply Chain

"A Supply chain is a set of three or more entities directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to customer" (Mentzer et al., 2001).

Now there are a lot of definitions of supply chain across different literature and most of them sound very similar. Although, if companies do not actively use the concept of supply chain, there still is a supply chain that exists in a business or the management of those supply chains (Mentzer et al., 2001). Mentzer et al (2001) also points out that the final customer is considered as an actor of the supply chain.

3.1.2 Definition and description of Supply Chain Management

"Supply chain management is the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within the supply chain, for the purpose of improving the long-term performance of the individual companies and the supply chain as a whole" (Mentzer et al, 2001).

Supply chain management is a philosophy which regards the supply chain with a system approach, where all activities and processes are viewed as one function. (Ellram and Cooper 1990; Houlihan 1988; Tyndall et al. 1998). That philosophy of supply chain management tries to promote a multiorganization effort and create a partnership to manage total flow of products from the supplier to the final consumer (Ellram 1990; Jones and Riley 1985). In such a way, SCM is a common coordination of each supply chain actor that directly and indirectly influences the total SC performance. (Cooper et al. 1997). Langley and Holcomb proposes that creation of customer value should be made in synchronization with all supply chain activities.

Once, the SCM definition is done, several characteristics of SCM as a management philosophy can be highlighted:

1. A systems approach to considering the supply chain as one function and the management of the total flow from supplier to the final consumer;
2. A strategic orientation takes place where cooperative efforts exist to synchronize and coordinate intra-organization and inter-organization operational and strategic resources to reach the same objective.
3. To gain customer value different sources are involved and individualized. Customer satisfaction appears as a main indicator of performance.

The integration and coordination of processes such as sourcing, distribution and production are part of supply chain management and play an important role (Cooper et al. 1997; Cooper, Lambert, & Pagh 1997; Ellram & Cooper 1990; Novack, Langley, and Rinehart 1995; Tyndall et al. 1998). Gentry and Vellenga (1996) state that activities such as inbound and outbound logistics, operations, marketing, sales, and service should be concentrated in one company to have high customer value.

It has been suggested by some authors that to build an effective supply chain, there is need of a management process. Davenport (1993) characterizes a process as a set of activities which are constructed to have distinct output for a special customer or market. Ross explains that supply chain process as the physical business functions, departments and operations that assist a particular supply chain to move materials, products or services to market through the supply chain. Lambert, Stock, and Ellram (1998) suggest that all companies within a supply chain have to get over functional silos and use a process approach. It means that all functions in a supply chain should be viewed as key processes. In process approach focus is on meeting consumer's demands and requirements.

3.1.3 Supply chain mapping

For easies understanding of the supply chain, maps are created by visualisation of information to get another additional view on an object. This chapter highlights what benefits a SC map can give to this study and how it will help to figure out processes and flows of the Scania SC.

The design of maps can be different depending on place of application and across subjects. A map is something that represents the environment with spatial relationships. A supply chain map is able to improve the planning process, information sharing and access to various actors, provide better communications, help with modification or re-engineering and create basis for analysis. For many people it is easier to comprehend information in pictures than in thousands of words.

Companies are becoming bigger and are expanding operations globally so managing, visualizing and tracing the supply chain activities are harder. Gardner at. al (2003) define a supply chain mapping as a visual representation of products, materials, information, processes and financial flow that exist in a supply chain both upstream and downstream. It should be noted that a supply chain map just shows the framework of the interconnections and does not give an opportunity to manage a supply chain. This is due to the lack of space for including all information and the map exists for strategic planning. A supply chain map is created to be sure that the supply chain matches the company strategy.

The purpose is to make changes in current operations and activities. A supply chain map has to present the relation between its members and the information flow of the entire stream Supply chain maps can

have different shapes and designs but they focus on a specific user. The maps can visualize departments, processes, flows or even facilities. A supply chain mapping is also known as a process map or flowchart. A process map focuses on understanding insights in a process, improving information sharing, communication and work coordination between internal stakeholders. It can also identify bottlenecks, gaps and interruptions. Process mapping aims to break down a process into activities and actions.

3.2 Processes

To understand and map the supply chain costs related to industrial packaging systems, processes and activities should be understood. A process is an activity or set of activities that have an input, output and add value to it. There are various types of processes such as customer processes, administrative and management ones. Anupindi, et al. (2006) explains four main characteristics of any process:

- it has to be predictable and have inputs
- it should be constructed in a defined sequence and be in a flow
- all activities are defined and tasks are confirmed
- output and results must be predicted and measured

All these characteristics as a whole can be converted to the standard transformation model which has inputs and outputs as well (Figure 2).

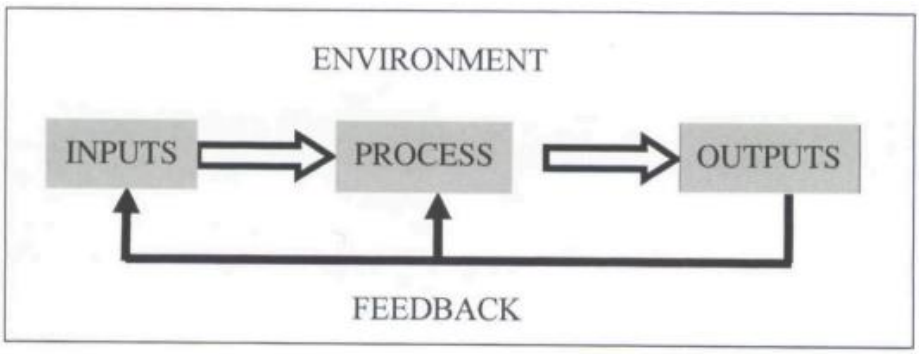


Figure 2 Process transformation model

This model shows activities at individual process-worker level or can display the entire process from the first step until it finishes.

Ljungberg and Larsson (2001) notes that the object initiates building of the process that consists of a series of activities where various resources are need to start them. In addition, there is a need of information support, control of the process and management. Output from the process is the object which triggers the next process.

Process also includes parts which are assigned requirements and evaluating criteria. Evaluation is based on indicators which can be documented in a specification and stakeholders of processes are responsible for them (Ljungberg & Larsson, 2001).

3.3 Logistics

In order to break down Scania supply chain into processes, packaging flows and logistics, a clear definition of Logistics had to be made in order to discuss, explain and address key features of this subject.

"Logistics is that part of the supply chain process that plans, implements, and controls the efficient, effective forward and reverse 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 logistics management, www.clm1.org, 2002-11-26)

It is important to point out that logistics is inextricably linked with supply chain, it assists in managing material flows and the information flow to reach customer satisfaction with reduced costs.

Last centur the role of logistics became significantly more important with increasing competition and more requirements from the markets. Logistics can have a lot of functions depending on the specific industry but in common it includes activities such as transportation, warehousing, inventories, order processing, packaging, materials handling, forecasting, planning and purchasing. (Lambert et al., 1998, p.435)

3.3.1 Transportation

After understanding the meaning of logistics and its main function, transportation is described as it is one of the main expenditures for packaging in Scania and this process will be studied during the master thesis project.

According to Chopra and Meindl (2013), transportation refers to "*the movement of product from one location to another as it makes its way from the beginning of a supply chain to thecustomer".*

Transportation takes an important role in every industry nowadays because of the globalization where manufacturing and trade companies receive supplies from different parts of the world. When the total production costs are calculated, transportation share is around twenty percent. When managers realize that it is a huge number, they start to pay more attention to the field. For managers costs is a key decision criteria when selecting the right mode of transport. Criteria such as service levels, capacity and transit time are also considered. The main trade-offs in transportation are efficiency against responsiveness, i.e. costs against transit time (Chopra & Meindl, 2013).

3.3.2 Warehouse and its activities

Warehouses play an essential role in any supply chain. All types of packaging go through various warehouses in the Scania SC and there are a lot of processes and activities which have costs. Literature support will assist to identify all warehouse activities. The main warehouse functions include: keeping

the buffer of physical flow along the supply chain to reduce deviations caused by different reasons such as product seasonality, smoothing production rate when batching in big volumes, consolidation of goods from various suppliers, combined delivery to customers and value-added-processing such as sorting, labeling, and packaging (J. Gu et al. 2007).

Persson and Virum (1990) divide operational activities in a warehouse into the following groups:

1. Loading and unloading of vehicles
2. Receiving and handling of goods in warehouse
3. Storing and inventory
4. Picking and preparation of shipping

Apart from these activities there are usually other activities too, but not everywhere. It depends on the design of flows and how the supply chain is organised. A good example is handling of returned goods. In receiving, materials are compared with the number of the delivery invoice. They should be checked for damages and other deviations. Depending on the type of warehouse management, goods location address is assigned and only after that is materials put away in the storing area (Persson & Virum, 1990). One of the main warehouse costs occur because of orders picking. There are different order picking methods such as single-order picking, batching and sort-while-pick, batching and sort-after-pick, single-order picking with zoning, and batching with zoning (Yoon & Sharp, 1996).

3.4 Packaging Logistics

All identified activities and processes in this thesis will be related to packaging and in order to connect packaging with logistics and the supply chain, the theory of packaging logistics must be studied.

European Parliament and Council Directive 94/62/EC defines packaging as follows:

"'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 can be categorized in to three different levels primary level, secondary level and tertiary level (figure 3). This categorization can be viewed differently based on the containment in those levels of packaging. these three levels of packaging can be described as,

Primary packaging: packaging that is in direct contact with the product is referred to as primary packaging. This type of packaging is also called consumer packaging in other contexts. The main purpose of primary package is to protect, contain, preserve the product and to inform the consumer.

*Secondary packagin*g: the main purpose of secondary packaging is for branding display and logistics as well as protecting and collating primary packages during storage. Sometimes it is referred to as retail package as it is meant for increasing manageability in stores.

Tertiary package: tertiary package is used to facilitate a number of primary packages or secondary packages for better handling, transportation and storing.

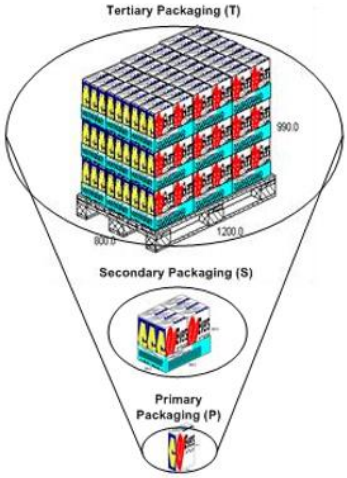


Figure 3 The system classification of packaging

Some of the packaging terms presented by Jönson G (2006) is shown in figure 4.

Packaging Type	Definition
Primary packaging, consumer packaging or sales packaging	Packaging which is in contact with the product. The packaging that the consumer usually takes home.
Secondary packaging	Secondary packaging is designed to contain several primary packages.
Tertiary packaging	Used when a number of primary or secondary packages are assembled on a pallet or roll container.
Group packaging	Packaging which is created to facilitate protection, display, handling, and/or transportation of a number of primary packages.
Transport packaging, industrial packaging, distribution packaging or bulk packaging	Packaging which facilitate handling, transport and storage of a number of primary packages in order to provide efficient production and distribution, as well as to prevent physical handling and damage during transportation.
Display packaging	Same as group packaging, quite often with an emphasis on display features.
Retail packaging	Same as group packaging with a special emphasis on the design to fit in retail.
Used packaging	Packaging/packaging material remaining after the removal of the product it contained.

Figure 4 Common packaging terms of use

Definition for packaging logistics by Saghir (2004) states:

"The process of planning, implementing and controlling the coordinated packaging system of preparing goods for safe, secure, efficient and effective handling, transport, distribution, storage, retailing, consumption and recovery, reuse or disposal and related information combined with maximizing consumer value, sales and hence profit."

Packaging affects the supply chain in several ways as it interacts with logistics, manufacturing, marketing and information systems. It also affects environmental performance in terms of waste handling and fill rate in transports. From a logistics perspective, packaging influences and is affected

by every logistics activity, such as the efficiency of warehousing, transport and manufacturing processes. Consequently, packaging has a great impact on logistics costs (Pålsson et al. (2011).

Azzi *et al.* (2012) argued although packaging impact on supply chain costs and performances can be overwhelming, packaging activities are often perceived as a cost rather than a value adding activity. Since packaging affects several supply chain activities, with interaction at several stages, packaging will add value in the supply chain.

3.4.1 Returnable packaging

As Scania uses returnable packaging in parts handling, this master thesis explains the role of that kind of packaging in the SC and the difference between different logistics system according to returnable packaging.

The Returnable Packaging Association (RPA) defines 'returnable packaging' as packaging which includes “reusable pallets, racks, bulk containers, hand-held containers and dunnage that move product efficiently and safely throughout the supply chain”. Kroon and Vrijens (1994) explains Returnable packaging in their famous article “Returnable containers: an example of reverse logistics” as a type of secondary packaging that can be used more than once in the same form (see figure 5). These returnable packaging can be broken-down into smaller packaging material, ex-removing collars from the packaging assortment. Reusable packaging is typically used by manufacturers and their suppliers/customers in a well-organized supply chain, with very tightly managed shipping loops.

Figure 5 Returnable packaging system

Besides the environmental benefits with reusing packaging, many companies have discovered that returnable packaging can also be commercially rewarding (Kroon & Vrijens, 1994).

*Return logistics systems***:** A consequence of the use of returnable containers is that, after a container has been used for carrying products from a sender to a recipient, the container has to be transported from the recipient to the next sender, who need not be the same as the first one (see figure 6). In addition to transporting the containers, the return logistic system also involves the cleaning and maintenance of containers, as well as their storage and administration (Kroon & Vrijens, 1994).

Three different types of logistic system for returnable packages according to Lützebauer are: switch pool systems, systems with return logistics, and systems without return logistics; Kroon and Vrijens (1994) defines these systems as following;

Switch pool system: In a switch pool system every participant has his own allotment of containers, for which he is responsible. Thus cleaning, control, maintenance and storage of the containers are the responsibility of each pool-participant. Pool-participants may be the senders and recipients, or the senders, carriers, and recipients of the goods.

Systems with return logistics: In this type of system the containers are owned by a central agency. This agency is also responsible for the return of the containers after they have been emptied by the recipient. The main prerequisite for such a system is that the recipient bundles the empty containers, and stores them until a sufficient number has accumulated for cost-effective collection.

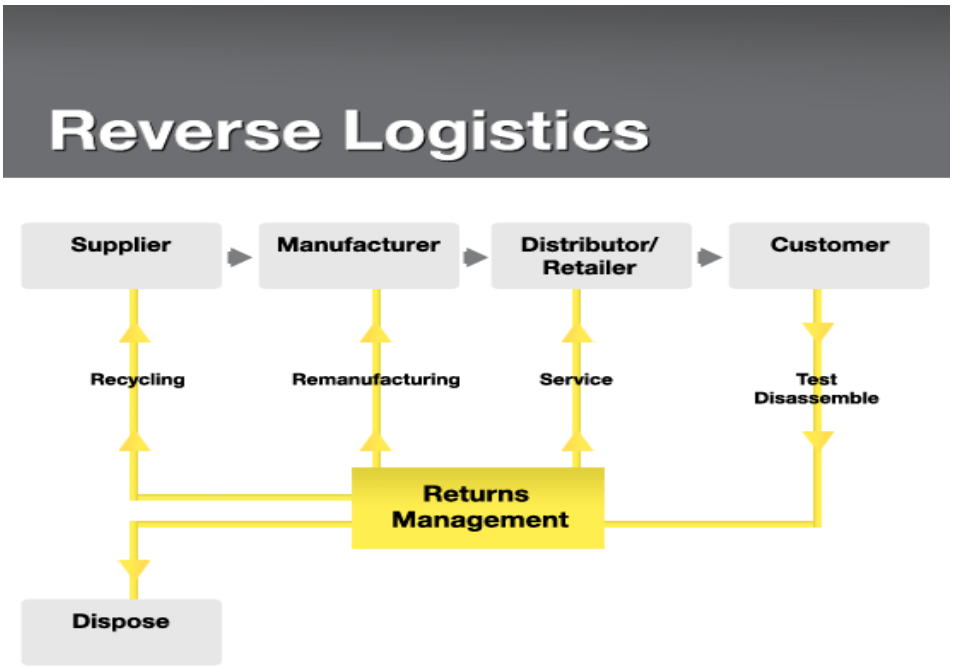


Figure 6 Reverse logistics system

Systems without return logistics: In this system the containers are also owned by a central agency. The user of this system, the sender, rents the containers from the agency. As soon as the sender no longer needs the containers, they are returned to the agency. The sender is responsible for all activities involving the containers, such as return logistics, cleaning, control, maintenance and storage. By using this system, the sender can decrease his fixed costs by renting varying numbers of containers as required.

3.5 Costing

This master thesis investigates returnable packaging in Scania supply chain but one of the key elements in this work is costs which indicates how operations work and how packaging can influence them. To start gathering costs two things are needed, an overview and what cost method will be used.

Costing methods: The total money, time and resources associated with a purchase or an activity is called a cost. In general there are two types of costs associated with any purchase or activity in case of manufacturing or production, fixed costs and variable costs. Total cost is the sum of fixed costs and variable costs. According to Ruth (2003), the Costing is important because it provides a quantified basis for defining forecasting resource gaps and needs, and for mobilizing additional resources, either internally or externally.

3.6 Costing models in packaging SC

Packaging affects the supply chain and interacts with logistics, manufacturing, marketing and information systems. Packaging has a central role in logistics and has high impact on its costs. (Ebeling CW, 1990). For example, utilisation efficiency in transport is affected by the size and dimension of packaging. There are systematic methods which aim to evaluate a packaging system and its impact on the supply chain. (Saghir M, Jönson G, 2001). Different methods can consider specific areas such as environment and cost influence. The most appreciated are sustainable packaging design, economic and environmental framework, supply chain issues in reusable packaging, concurrent packaging and product design.

Sustainable packaging design is an approach which groups several analytical methods. It considers two evaluation criteria, the environmental performance of the packaging system and the total distribution costs of packed products. The total distribution costs of packed products consider all costs related to packaging. It can be costs of packaging material, packaging process, transportation from production to end customer, handling and product loss.

The economic and environmental framework applies a value stream model to get the description of the material flow, which includes packaging. This method uses aggregated secondary data sources and the total cost analysis works as a support to the method.

Twede and Clark (2004) investigate and test relationships of reusable packaging systems in supply chains. They state that reusable packaging is not applicable for every product or logistical system and different supply chain factors should be considered to reach potential success. Supply chains which can get benefits from reusable should have such characteristics as short lead time and shipping distances, efficient sorting, cleaning operations and implemented tracking system.

Bramklev C (2009) states that packaging development must be integrated with the development project of products to increase efficiency and effectiveness. It can reduce the consumption of raw material for packaging and avoid a costly product solution. In this model of packaging design various processes are involved such as packaging planning, packaging system development, package concept development and package production system.

3.7 Activity Based Costing (ABC)

CIMA (Chartered institute of management accountants) defines ABC as an approach to the costing and monitoring of activities which involves tracing resource consumption and costing final outputs. Resources are assigned to activities, and activities to cost objects based on consumption estimates. The latter utilize cost drivers to attach activity costs to outputs. By considering all of these results ABC can identify value-added activities as well.

ABC methods have drawn interest in supply chain management because it can identify the cost attached to each level of activity. ABC traces the consumption of resources by identifying "activity cost drivers" which traces particular cost objects such as specific products and services (Binshan, 2001). These activity cost drivers can be measured quantitatively and used to calculate total packaging costs.

Jongkyoung Kim (2014) explains that in order to determine packaging costs in a supply chain, it is important to understand that packaging not only consists of materials, but is also associated with many activities such as packing, unpacking, filling, palletizing, etc. Many activities are directly or indirectly mixed with supply chain activities and these are very hard to convert to financial terms. ABC aims to identify the cost attached to each level of activity (e.g. cost per item picked, cost per delivery, etc.). ABC can present a clearer picture of the true packaging and logistics costs. Activity-based costing (ABC) has been introduced as a more reasonable cost accounting method in order to find and measure accurate and realistic cost allocations in a company. While traditional accounting methods allocate indirect costs to direct costs or direct labour costs, ABC attempts to turn overhead (indirect costs) into direct costs based on the number of activities related to the products (Varila *et al.*, 2007).

3.7.1 Application of ABC

The main elements of ABC are *resources*, *activities*, and *cost objects* (Damme & Zon, 1999). ABC traces the consumption of *resources* by identifying *activity cost drivers* which traces particular *cost objects* such as specific products and services (Binshan, 2001). These activity cost drivers can be measured quantitatively and used to calculate total product costs. Kim created a simple ABC model in general (see figure 7).

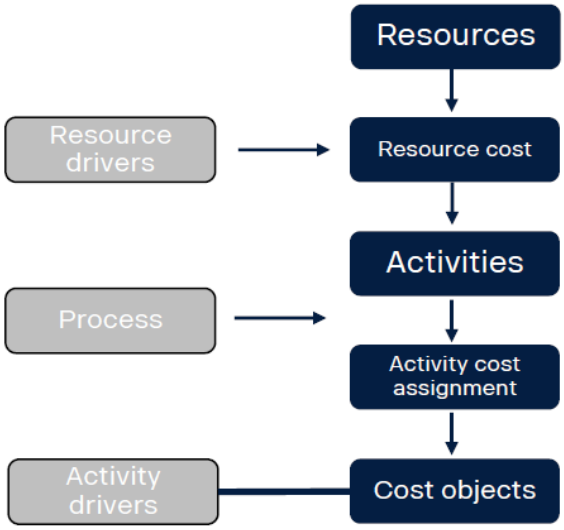


Figure 7 General principle of an ABC model

Resources: these are economic elements that are required to perform an activity, e.g. employee salary, handling equipment cost. Therefore the cost related to the resources are amount of resources used for the activities to be done. Resources can be either products or services depending on the activity to be performed.

Resource drivers: These are trace expenditures of the resources that are required to work activities. The meaning of resource driver in this context is that the resource driver will express the use of the resources for respectable activities. As an example, product shipment is a resource and the resource driver is weight (kg).

Activities: Activities are an aggregation of actions performed within an organization. These activities within the organization consume resources to perform an operation (Baker, 1998, pg.4). There are several examples for activities such as maintenance and unloading pallets from truck. Activities can either be work tasks, services or processes. As shown in figure 8 (Gerdin, 1995, p.66), activity is a resource transformation process where resources are used as an input.

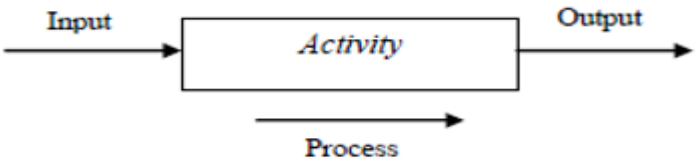


Figure 8 Activity seen as a resource transformation process (Gerdin, 1995, p.66)

Cost Objects: Cost objects are any product, service, contract, project, or any other work unit for which a separate cost measurement is desired (Baker, 1998, pp.4-5). Jongkyoung Kim states that cost objects are the "final good or service created as a result of the performance of an activity or of a chain activities".

Cost Drivers: according to Baker (1998, pp 5), cost drivers are any factors that causes a change in a cost of an activity. An activity may have multiple cost drivers associated with it. The allocation bases are used for applying costs to, example, services are called cost drivers. They include any causal factor that increases the total cost of the activity. For the material transport activity the cost driver might be total distance transported, number of transports etc.

3.7.2 ABC process in supply chain management

The ABC process for supply chains are broken down into 7 steps by Lin, Collins, & Su, 2001, those are:

1. Analysing supply chain functions
2. Breaking processes down into “activities”
3. Identifying the “resources” consumed for activities
4. Determining the cost for each activity
5. Determining “activity cost drivers”
6. Collection of activity data
7. Calculating the final cost.

4 Empirical findings

This chapter will present empirical findings for this thesis work.

4.1 Scania background and organization structure

Scania operates in more than 100 countries and employs around 49200 people, end of year 2017. Research and development are concentrated to Sweden, with branches in Brazil and India. Production takes place in Europe, Latin America and Asia, with regional production centres in Africa, Asia and Eurasia. Scania is part of Volkswagen Truck and Bus GmbH. Scania is a world leading provider of transport solutions. Together with partners and customers Scania is Driving the shift towards a sustainable transport system. In 2017, Scania delivered 82,472 trucks, 8305 buses as well as 8,521 industrial and marine engines to the customers. Net sales totalled nearly SEK 120 billion. Scania head office is located in Södertälje Sweden. Manufacturing of parts for the European market is done in three locations in Sweden, Södertälje, Oskarshamn and Luleå. Manufacturing of engines, gearboxes, retarders, transmission articles, front and rear axles is done in Södertälje. While Luleå manufacture rear axle housing, bumpers, cross and side beams and Oskarshamn is responsible for the production of cabs for trucks. The assembly of chassis is in addition to Södertälje done in Angers, France, Meppel and Zwolle in Netherlands.

The core of the Scania CV AB's operations is manufacturing heavy trucks (above 16 tonnes in gross vehicle weight). Scania is the fourth-largest producer in the world in this segment. Besides producing trucks, Scania produces buses and coaches as well as industrial and marine engines. Alongside focusing on the core product, services such as financing and maintenance make up an increasing part of Scania's offer to its customers. Figure 9 shows the business overview of Scania for the most recent four years. It is evident from the values that the net sales of Scania is increasing.

Figure 9 Business overview of Scania

4.2 Current packaging system

For many years Scania has used returnable packaging for inbound logistics of automotive parts. From the beginning each production unit was responsible and cared for its own packaging. There was a lack of a centralized system and management of packaging processes. The collaboration that existed was between the different production units. An organization, currently named Packaging Supply (OID), was launched to create a centralized control unit for Scania's packaging processes.

Scania packaging can be divided into two groups:

Standard packaging: To Scania standard packaging belongs what Scania name category 1. Most pallets, pallet collars, lids, and simple spacers are under this category (Picture 1). Some time ago, plastic boxes were introduced and started to be used under this category. Spacer is a part of packaging which is used inside a pallet to keep products without any turbulence. It is usually made from plastic. Scania call packaging parts material handling (MH) numbers. Each packaging MH has a unique number. MH is mostly not an independent packaging but separate objects of packages such as pallets, lids, spacers and collars which are not able to deliver any parts. Sets of MHs creates packaging which can handle parts. A set is usually one pallet, collars, one lid and a few spacers and pictures below shows the packaging material that can form into one complete packaging assortment.

Picture 1 Main packaging parts

There are seventy four MH numbers. They are based on pallet size and includes S-pallet, Euro pallet, Half Euro pallet, L-pallet, M-pallet, Q-pallet, T-pallet and X-pallet. Different packaging are created by adding various numbers of MH such as collars, lids and spacers to the pallet. s showed in table 2 these are 17 MH numbers that contribute to maximum volume, it can be seen that Euro Pallet is most used type of MH in the supply chain.

Standart packaging		
MH-number	Description	% of total volume
1872	e-collar	14.76%
1875	E-pallet	17.69%
2318	e-lid	3.90%
150	E-spacer	1.54%
250	Foam e-spacer	4.10%
5043	e spacer	0.0022%
1871	H-collar	3.93%
1874	H-pallet	6.54%
2319	H-Lid	1.52%
140	H-SPACER	0.75%
5116	runner h-pallet	0.0011%
3147	Box B1	2.59%
4147	Box B2	2.65%
6147	Box B3	3.37%
4051	spacer(boxes)	0.0001%
143	MINIBOX	0.68%
164	Small Box	0.88%
166	SB-spacers	1.50%
7555	T-pallet	2.16%
7556	T-collar	1.83%
7557	T-Lid	0.35%

Table 2 MH numbers in Scania packaging system

Packaging can also be created by adding collars on the pallets. For half euro pallet and euro pallet maximum level of collars is five, for X-pallet eight, for M and T-pallet six collars. All of them differ on dimensions such as width, height and length (see table 3). Moreover, packaging also can appear as boxes for example B1, B2, B3-Box, MiniBox and SmallBox.

Special Packaging is developed for a specific part or specific part requirements. Special packaging is used rarely, only when standard packaging is not able to fulfil the requirements. Today Scania has 515 types of special MHs and if one were to consider its share in total volume, it accounts for only 12%. The most pertinent special MH is “lift yoke kpl” (0,85% of total volume).

Scania also uses one-way packaging which mostly but it is out scope of this master thesis.

Code Name	CN Description	CN_WIDTH	CN_HEIGHT	CN_LENGTH	CN_WEIGHT
00	S-PALLET	1200	160	1600	39,00
10	EURO PALLET	800	150	1200	24,00
20	HALF EURO PALLET	800	130	600	12,00
40	L-PALLET	800	160	2200	45,00
B1	B-BOX	198	147	297	0,57
B2	B-BOX	297	147	396	1,08
B3	B-BOX	396	147	594	1,09
B4	BOX	400	220	600	2,48
M0	M-PALLET	1000	150	2300	55,00
MB	MINIBOX	300	200	400	2,20
Q0	Q-PALLET	1100	169	1100	56,00
SB	SMALLBOX	400	200	600	4,10
T0	T-PALLET	800	150	1600	30,00
X0	X-PALLET	1200	160	2650	69,00

Table 3 Dimensions of Scania's packaging

4.3 Global Supply chain of packaging

In order to understand the packaging influence on costs and in which processes they occur, the supply chain of returnable packaging has to be investigated.

The packaging supply chain provides a pool based system of returnable packaging for transport of goods from suppliers to production units, as well as for use within and between the production units. Scania's packaging supply chain is a complex process with many actors and working globally (see figure 10).

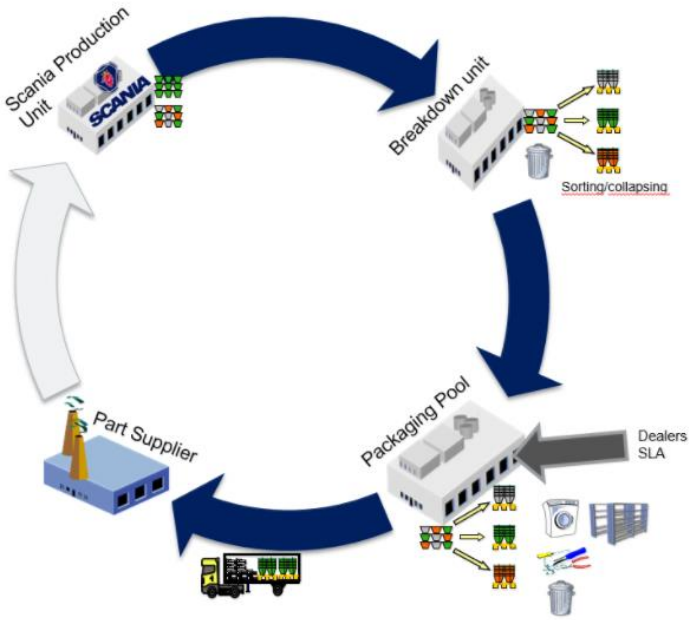


Figure 10 Simplified illustration of Scania packaging supply chain

3.4.1 Part suppliers

To have clear understanding of supply chain actors, we call a manufacturer of automotive parts supplier. Suppliers of parts are mostly located in Europe and they fill empty packages with parts which are delivered to Scania production sites through Scania's transport network.

3.4.2 PRU

Scania's own production units are called PRU (Production Unit). A PRU can be a processing unit or an assembly unit. A PRU can be seen as a customer of packages. A PRU use many different types of packages, some of them the production sites themselves are the owner of, others are OID or some other unit. Most of the need of packaging is satisfied from incoming goods that are packed in packaging. When a PRU consumes an automotive part, the packaging becomes empty and there is no more need to keep it in production. Packages are returned to break down or pool thus creating a closed loop.

Scania have 13 PRU's in Europe;

Sweden

Luleå

- DL (Ferruform)

Södertälje

- DE (Engine Production Assembly)
- DM (Engine Machining and Foundry)
- DX (Gearbox & Axles Machining)
- DT (Axle and Gearbox assembly)
- MS (Chassi Assembly trucks and busses)

Oskarshamn

- MB Cab body production Oskarshamn
- MC Cab Assembly Oskarshamn

Zwolle

- MZ (Chassi Assembly trucks)

Meppel

- MM (Painting)

Anger

- MA (Chassi Assembly trucks)

Slupsk

- KBM (Bus Workshop)

Lahti

- KBM (Bus Workshop)

3.4.3 Break Down (BD)

The Break down unit is used to break down or sort packages that comes from different PRU's. Packages that is released in PRU's are often not sorted according to the packaging instruction for a distribution unit of empty MH. Today there are 5 BD units in Scania Europe, two in Södertälje area, one each in Oskarshamn, Zwolle, Anger and Meppel. The focus in this thesis is only the break downs in Södertälje.

3.4.4 Packaging pool

Pool units are depots that Scania use to store empty MHs (and in a few cases wash and repair packaging). Scania use four major pools in Europe, one in Oskarshamn that they own, one in Södertälje, one in Eschweiler and one in Birmingham. When suppliers have a demand of MHs, they order it from OID that optimizes and combines the orders. Packaging pool is responsible for printing orders, picking and shipping MHs.

4.4 Supply chain of this study

This thesis focuses on the following Scania supply chain actors, part suppliers from Europe, logistic centre, Chassis Assembly, Break Down and Packaging pool (Figure 11). With exception of VIDA and suppliers, all other SC actors are located in Södertälje, Sweden. The transportation network is also included in this study as it plays an important role in the supply chain due to high costs in logistics. Chapter 4.5 presents descriptions of all activities and processes associated with packaging in the focused supply chain.

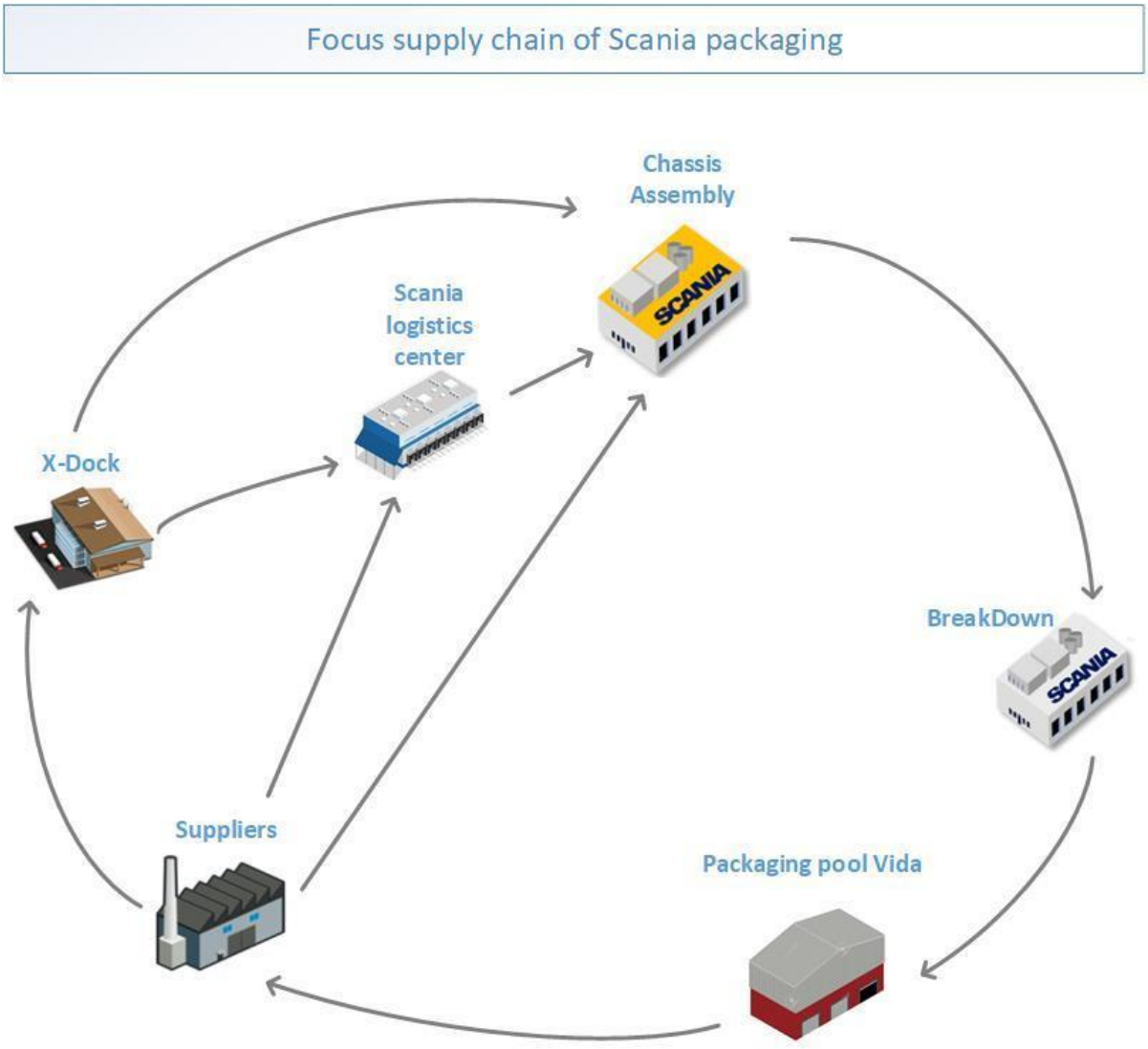


Figure 11 Focus supply chain of Scania packaging

4.5 Activities related to packaging at chassis assembly

Chassis assembly is one of the Scania PRU's in Södertälje and which is responsible for final truck assembly from various components and parts. This supply chain actor handle a wide range of parts and logistics processes are performed with a high complexity. Chassis Assembly related flowchart can be seen in figure 12.

4.5.1 Receiving

First, reception will get notified about the time of arrival of goods through an information system called Webstars. Packages are delivered directly from suppliers or from X-docks of Scania. Reception prints labels for the packaging assortment and these labels include information about which storage area the packaging assortment should be transported to for storing before delivering the parts to final consumer. This is done with the help of the warehouse management system called SIMAS. SIMAS also specifies the storage location for the assortment in that particular storage area. The packages from the truck are unloaded using forklifts and usually one forklift driver is assigned for this operation. According to personnel working at the reception there is no standard time for unloading of each truck so the unloading time depends on the total orders and pallets that needs to be unloaded. Received assortments are stored under the roof according to the time slots that they are delivered. Since the assortment will be moved to different storage areas after they were delivered it will be more efficient if they were sorted according to this criteria. However, these delivered assortments are not sorted according to storage area but according to the timeslots they are delivered in. Pallets which contain boxes are placed close to the conveyer area where these pallets will be placed on a conveyor which carries them to the box storage.

Empty wagons are parked inside the reception area and pallets will be loaded on to these wagons which will transport them to the storage areas that they are assigned to by SIMAS. Loading of pallets on to the wagons is done by forklifts, so it is the duty of the forklift driver to load correct pallets on the right wagons. Bigger pallets like U-pallets are transported directly by forklifts to the storage area. Two storage areas (231 and GMT) are very close to the reception area so the pallets which will be stored in these storage areas are put away directly by forklifts without wagons. Some of the special packages are not stored under the roof or at reception area before instead they are directly sent to storage locations close to consumption area by forklifts. According to personnel working at reception, the maximum storing time before they are put away is less than 2 hours.

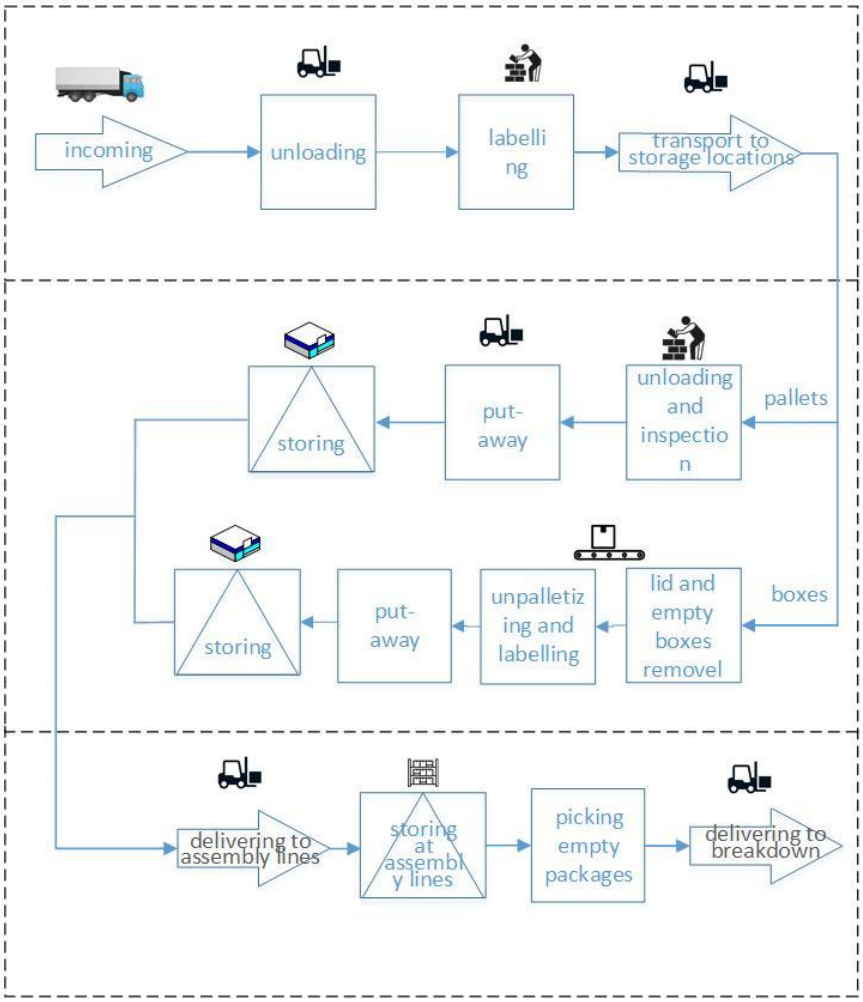


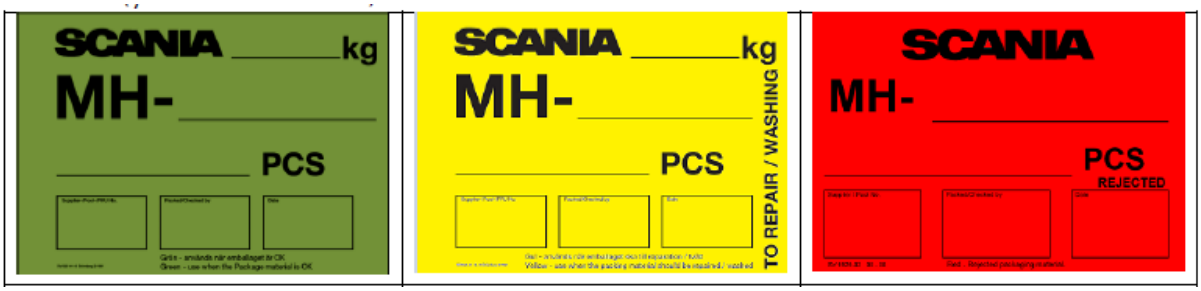
Figure 12 Process map of packaging at chassis assembly

4.5.2 Labelling

One or two labour personnel is dedicated for the stapling of labels on the pallets. These labels are generated by SIMAS. Labels are put on each pallet so this implies that changing the size of the packaging assortment does not have significant impact on the labelling. When packaging is emptied, it goes through BreakDown where it is decided, what type of labels are put on the empty packaging. Three different types of labels is currently in use, those are presented in table 4 with their denotation. Picture 1 show how those labels look like.

	GREEN	**YELLOW**	**RED**
DENOTATION	Distribution units ready for delivery	Units that needs to be repaired or washed	Units that will be scrapped

Table 4 Types of labels



Picture 2 Labels of empty packaging

Transportation to storage location: Moving of pallets from reception to storage areas is done by industrial wagon carts and forklifts. As mentioned in receiving, pallets moving to storage area 231 and GMT are done by forklifts. Wagon carts are used for storage area 236, 220 etc. Two wagon carts are attached to each other for efficient transportation.

4.5.3 Storing

Pallet storage: once the pallets are unloaded from the wagon carts by forklift, these will be staged for put away. Labels printed at reception will guide the forklift drivers to put away the pallets in the shelves or on the floor according to the storage location specified on the label. This label consists of rack number, row and column number and level of shelf on which the pallet should be stored. Shared storage principle is used in all the warehouses, meaning the storage locations are not dedicated for particular articles or SKUs which Scania calls a floating storage system. Most of the storage locations in the tents (231,GMT, 236) are dedicated only for E-pallet and H-pallet. Other different types of pallets are stored on the floor which eliminates efficient usage of storage space in the tent. In general, there are different types of storage shelves in the racks based on the stack height. At the bottom level (0 level or floor storage), pallet with maximum two collar height can be stored. First level is dedicated for pallets with just one collar. Second and third level is for pallets with two collars. Fourth, fifth and sixth level is for pallets with three collars, four collars and five collars. The top storage location is for pallets with more than five collars which cannot be stored in any of the shelves inside the racks.

When the orders are received from assembly line or platform, order receipt consists of storage locations of all the orders for that particular request. The request also specifies the picking quantity so if the ordered quantity is less than the pallet quantity then the picker will pick only that sum of products from the pallet. In case of full pallet pick-up, after the pallet is picked from its storage location, these pallets will be stored at the shipping location staged for moving to order location. Once all the orders are placed at the shipping area then stapling of labels will be done by picker which mentions the delivery location. FIFO principle is adapted for picking of full pallet or less than pallet quantity which is done by the warehouse management system. Empty pallets from the storage locations which are not picked in full pallet quantity will be picked by the same picker and moved to shipping area for breakdown.

Box storage: Conveyor close to reception area is used to move pallets which contains boxes on them to a box storage. Pallets will be placed on the conveyor at the reception and these will be received at the other end of the conveyor close to box storage. Empty boxes from the complete packaging assortment are removed at the entry into the sorting area. One labour personnel is dedicated for this operation, sorting these empty packages to form a complete package assortment is also done by the same personnel. The reason for empty in packaging assortment is to enable stacking of pallets on each other which results in efficient fill rate for transportation, storing and handling. Two labour personnel is

responsible for picking boxes from pallets and placing them on roller racks which will be used for moving boxes to storage locations. So handling of boxes for put away and sorting operation is manual. Once the boxes are removed from the packaging assortment completely the pallets will be transported by forklifts to wagon cart which will be situated close to the sorting area. This wagon cart will be moved to breakdown once every hour.

There are two different types of storage locations (racks) in the storage area for boxes. One type is dedicated only for B1 boxes and the other is for B2, B3, Mini Boxes and Small boxes. B1 boxes constitutes most of the operations in the warehouse which also means it has a high share of locations compared to other types of boxes. However, all the warehousing operations (put-away, storing, picking and shipping in this case) for different boxes is same.

There is storage for high moving parts close to the sorting area. These high moving parts are stored as they are shipped from suppliers, on pallets. Forklifts are used to move these pallets to the storage locations. These high moving parts are mostly delivered in boxes on E-pallet or H-pallet and the storage locations are designed for these pallets. Picking of boxes from these pallets are done manually by the picker.

4.6 Breakdown

Figure 13 presents the flowchart of processes at Breakdown.

Receiving: Empty packages are received in wagon carts from different production units. Maximum share of empty packages are delivered from chassis assembly which is almost two thirds of all packages received. Two forklifts are dedicated for put away of pallets from the wagon carts to different locations at the receiving. There are three different types of locations at the receiving. One type is for pallets with boxes on them, these boxes are stacked and are ready for delivering to packaging pool for sorting and washing. Two other types are differentiated based on the type of pallets they receive from production units. One location (Loc. 1) is for E-pallets and H-pallets which will go to 270 breakdown and the other location (Loc. 2) is for other different pallets (mostly bigger pallets than E and H pallets example, M-pallet, X-pallet etc) which will then be moved to a tent for dismantling of packaging material and removal of spacers and one way packaging.

Two forklifts are dedicated for put away operation of empty packages from Loc. 1 onto the conveyor. Even though both the conveyors are designed to carry E-pallets or H-pallets, their purpose is defined differently. One conveyor (conveyer 1) belt is responsible for moving complete empty packaging assortment with spacers, lids, foam spacers inside them for breakdown. Second conveyor (conveyor 2) is used for packaging assortment containing special packaging material(ex, epe divider, flywheel spacer etc) in them to breakdown. These pallets are identified by forklift drivers based on the colour of the label that is stapled to pallets.

Breakdown: The main function at the breakdown is to break the packaging assortment into respective packaging material and ship them to shipping area. At conveyer 1 the main activities performed from one end to other end of the conveyer is, removing labels that is stapled on the collars, removing collars from the assortment and placing them on a pallet. Once these collars are removed additional packaging material such as lids, spacers and foam spacers are removed from the pallet and are stored into the pallets(pallet with 2 or 3 collars) that are placed next to the conveyors. These additional packaging materials are stored separately into different pallets depending on the type of MH. Two forklifts are

assigned to move these pallets once they are full with MHs close to the wagon cart parking area. After all the MH numbers is removed from the pallet, the pallets are stacked on each other for better space and handling utilization (see picture 2-4). Labour dedicated for stacking these empty packages are responsible for inspection of Scania's quality requirements according to packaging instructions before they are bundled or stacked. Handling of empty H-pallets are done manually for stacking (or bundling) whereas semi-automation is in place for E-pallets.

11 E-pallets are stacked for one assortment, two stacks of H-pallets are used as distribution unit for empty pallet stacking for half-euro pallet, so 30 H-pallets constitutes one packaging assortment. This process of stacking pallets is referred as bundling at Scania.

Picture 3 Stacking of empty E-pallets

Picture 4 Stacking of empty H-pallets

Picture 5 H-collars stacked on one e-pallet

Picture 6 E-collars stacked on 2 collars

According to logistics developer at breakdown, a total sixteen labour personnel are working to perform all these activities (2 shifts = 32 labour personnel a day).

Shipping: as mentioned in the previous section, two forklifts are dedicated to move full pallets with packaging material to the shipping location before they are loaded onto wagon carts by another forklift driver. In case of pallets, they are kept on the conveyor which is used to move stacked empty pallets closer to the wagon cart parking area. Automatic strapping is done at this conveyor for pallets and then they are removed from the conveyor and loaded onto a wagon cart. Once the wagon carts are full they are moved to the loading area outside the building. One forklift driver is dedicated for unloading pallets from wagon carts and to load them onto a truck. It takes between 3-4 minutes for one forklift driver to unload all the pallets from the wagon cart. This forklift driver will load the correct pallets onto the truck with the help of labels stapled on the pallets. Wagon driver will park this full wagon cart outside and will attach the empty wagon cart to the drag truck to move them to shipping area inside the building. This saves the time taken to unload the pallets from the carts (which is almost 3-4 min excluding attaching empty wagon carts to drag truck).

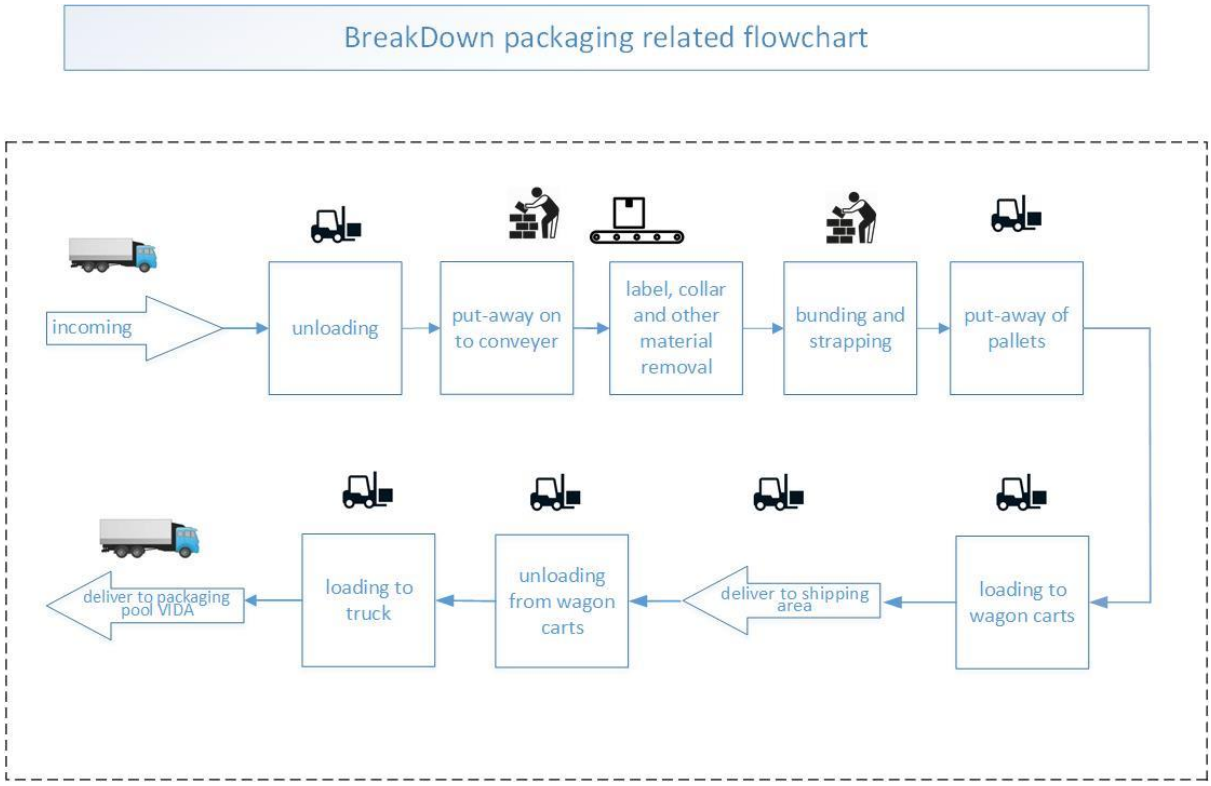


Figure 13 Process map at Breakdown

4.6.1 Pool

Receiving

Empty packages are received from three sites:

- breakdown;
- chassis assembly;
- engine plant.

Figure 14 shows process map of packaging pool VIDA.

All those packages are delivered by trucks and received according to a schedule. The pool has three receiving areas which are placed based on received types of packaging and their volume. To unload one full truck it takes between fifteen to twenty minutes.

First receiving area (receiving 1) gets five trucks in a day with empty boxes filled in pallets.

Second receiving area(receiving 2) is located close to the hall number 5 where mostly E-pallets and H-pallets are stored. This area receives seventeen trucks in a day. Eighty percent of received materials are directed to hall 5. Other twenty percent are distributed to other halls.

The last and third receiving area(receiving 3) takes place beside the inbound gate and it handles packaging material only from engine plant.

In total there are 3 forklifts dedicated only for receiving area and one more forklift acts as an assistant in case more orders are received than planned.

Breakdown

There are two breakdowns, the fist breakdown is dedicated for packaging material receiving from engine plant and the other one (breakdown 2) is for received packages from breakdown in Södertälje (building 270). First breakdown (B1) is designed to handle distribution units such as E-pallets and H-pallets. After materials are received, forklift driver put them on the conveyor which starts outside the hall D and afterwards enter the building. The function of conveyor is to carry materials forward with a pre-defined velocity. Around conveyor there are supportive machines and mechanisms which remove lids and collars automatically. Nevertheless, labor is also involved in that process as they have to pull out additional materials and remove used labels as well. There are twelve people working in that process and one team leader who establishes time plan and assures that the team addresses all operational tasks. After finishing breakdown process, packaging materials are transported by forklift to a storage area.

The second breakdown (B2) is aimed to breakdown packaging materials obtained from first receiving area. That flow consists from plastics boxes such as B1, B2, B3 and Minibox that are sent stacked on pallets. When the packaging is unloaded, it is stored outside the building, then it is placed on the conveyor and is delivered inside the building. After that, employees take off packaging and put it on a special table where packaging materials are folded to units of pallets, boxes, collars and lids. Labels are also removed manually. In that area employees make a decision on if it should be washed which is the next operation after breakdown. In total there are seven people working on break down and one more person works on moving materials that are not washed to storage area.

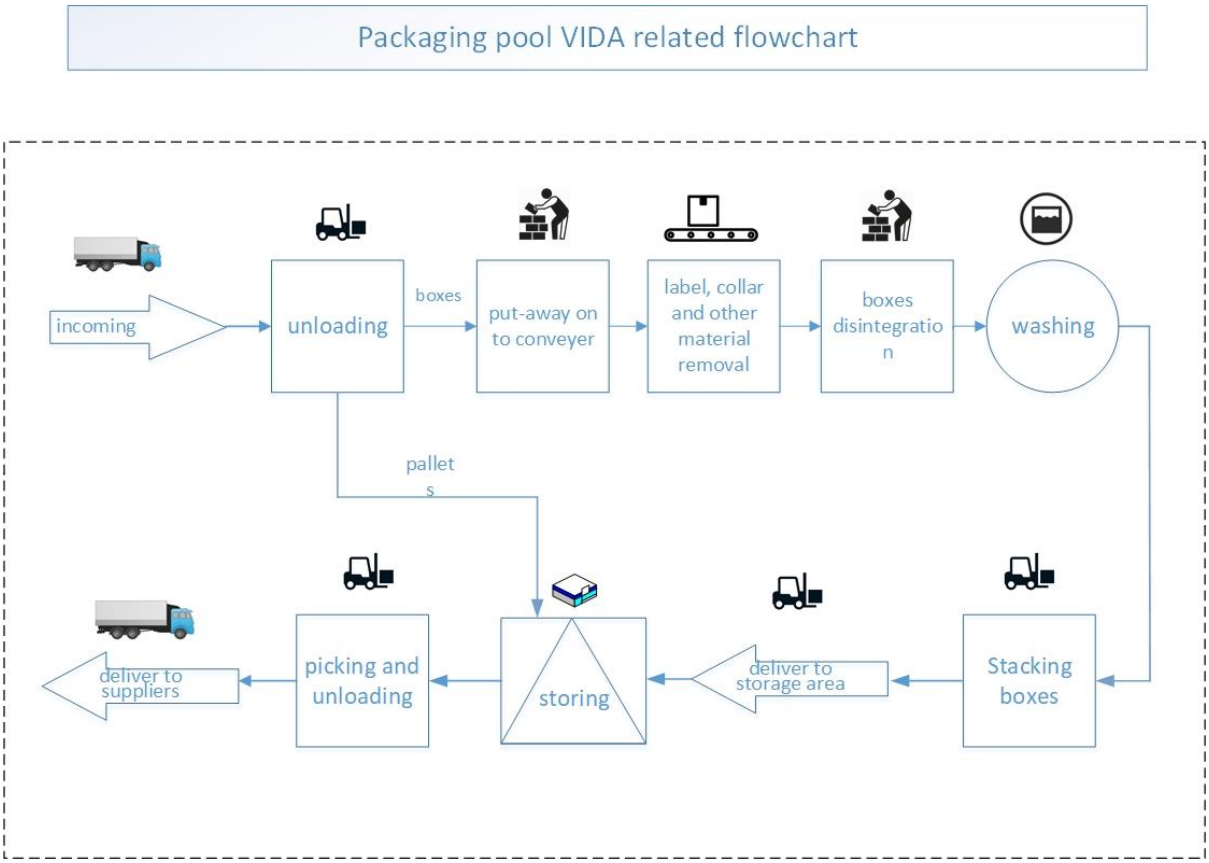


Figure 14 Process map at pool VIDA

Washing

Some types of packaging material have to be washed as they get dirty during transportation from suppliers to PRU. Mostly it is boxes and plastic spacers with lids. Packages must be sent back to suppliers in good conditions. Statistics from VIDA database counts that eighty percent of all plastic materials are washed. There are seven washing machines which clean materials such as lids, spacers and boxes. Eight employees are responsible for managing machines, control and sorting of packaging. After materials are washed, they are put on a pallet, wrapped, strapped and are moved by forklift driver to a storage area.

Storing

One of the pool's main functions is to store packaging material until they are ordered by suppliers. Materials are stored in six areas. Five of them are constructed as tents without heating or concrete walls. The sixth one is designed as a typical building with load-bearing walls. Packaging materials are stored on metal racks and the floor. Slow-movers are stored on the racks as the volume of this packaging material is very low and it is always easy to pick them. Most of the packaging materials are stored on pallets under the roof. Storing is based on FIFO management method in order to not keep materials at the back of the warehouse there forever.

Picking and shipment

Packaging materials are sent to suppliers by trucks which are loaded by forklifts. Trucks come to pool according to a schedule and park inside the pool yard.

4.7 Internal transportation

Internal transportation relates to all packaging movement between Chassis Assembly, Breakdown, Logistic centre and also inside them. Internal transportation is performed by forklifts, drag truck, wagons.

The supplier of all trucks is Linde company. It provides both electric and diesel trucks. Table 5 presents the list of all common trucks used in Scania logistics and monthly fee for renting and maintenance.

Truck	**monthly fee in SEK**
MOTVIKTSTRUCK H50D	11 232
DRAGTRUCK P250 SWB	9 622
MOTVIKTSTRUCK H35D	10 578
MOTVIKTSTRUCK E20-600H	9 253
MOTVIKTSTRUCK E16PH	6 882

MOTVIKTSTRUCK E20PH	7 790

Table 5 Used trucks in Scania logistics

Letter H in truck name means that it is based on diesel fuel, where E means that the truck works on electricity. Letter P means that truck is used for dragging some objects as wagons or other transports. In Scania, diesel forklifts do not operates indoor according to regulations and for safety reasons. Picture 6 shows the most common forklift, which works in many areas such as receiving, picking and put-away. Picture 7 presents forklift which mostly delivers boxes to assembly lines.

Picture 7 Common forklift for pallet handling

Picture 8 Common forklift for box delivery

On picture 8, can be seen a drag truck which drags wagons designed for pallets. It usually can have two wagons behind itself.

Picture 9 Drag truck used for dragging wagons

4.8 Part Suppliers

Suppliers who receive returnable packaging from Scania is termed as a parts supplier in this project. When Scania material planning department orders parts from the suppliers then parts suppliers can order returnable packaging material from Scania. For information, not all the parts suppliers receive returnable packaging and instead they use one-way packaging. It is decided by Scania which parts are better to receive in which type of packaging. Even though returnable packaging is considered as a closed loop flow system the number of packaging that a parts suppliers receive is totally dependent on the order size.

Since it is complex to calculate generalized costs for all the suppliers together concerning returnable packaging a compromise has been used. The project authors have decided not to include part suppliers in the ABC costing model but instead provide information about the main activities that will be impacted if there is any changes in the packaging assortment. Since the costs related to the activities for returnable packaging at suppliers facility is taken care of by parts suppliers itself authors are going to provide information about what will be the main impactable activities if there is any changes in the packaging assortment.

Project authors have visited three different types of part suppliers facilities to gain knowledge about the main activities related to returnable packaging that they receive and fill parts into and then send back to Scania. From the interviews and direct observations done at the part suppliers facilities it was evident that the major activities concerning returnable packaging are basic warehousing operations, those are receiving, put-away, storing, picking, filling packages with products, packing, repacking and shipping.

Parts suppliers orders parts through Embasy (IT tool) based on the material order they received from Scania. Currently the amount of packaging material that parts suppliers order from Scania is decided by parts suppliers themselves based on the part orders they received from material planners at Scania. The packaging material is then delivered to the parts suppliers facility. Scania has a set a guideline that the unloading and loading of returnable packaging from the truck or any other type should be done only with forklifts. So assuming all the parts suppliers follow this guideline, the major resource for receiving then would be forklift and forklift driver.

After the parts are unloaded then they are moved to a storage area that is dedicated by parts supplier for Scania returnable packaging material. In most of the cases the storage area is shared with other customer's packaging material at the part suppliers. OISP defines that all the returnable packaging material that a part supplier receives from Scania should be stored under roof. When the parts are ready to be filled into the packaging material these returnable packaging material will be moved from storage to the packing area.

The packaging material that part suppliers received is not a complete assortment but individual packaging material. To complete the packaging assortment parts suppliers either build that in a different place than the packing area or build at packing area based on their convenience. The packaging assortment is based on the guidelines that OISP provides.

From the observations there are two types of packing areas at the part suppliers. One type is, first the parts are filled into supplier's own packaging material and then refilled into Scania packaging. Second type is, parts are directly filled into Scania returnable packaging material. There are two different types of filling parts into packaging, one is manual filling and the second is filled by robotics(automation).

Once packages are filled with parts then they will be transported or moved to the storage area dedicated for packages filled with parts. The waiting time before they are loaded onto the truck to send it to will vary for different part suppliers. As explained before loading of these packages with filled products needs to be handled by forklifts which was true in all the three parts suppliers that authors visited and this was also true for unloading empty packaging material.

4.9 Logistic centre

Logistic centre is part of focus supply chain and it has the role of internal distributor of parts to different production units. It is placed close to Chassis Assembly and has the same building as breakdown. Logistic centre has all distribution functions including receiving from suppliers, storing, picking and shipping to internal customers. In addition, it also has the function of repacking incoming parts to more suitable packaging units.

The packaging flow starts with receiving parts where trucks arrives and they are unloaded. In unloading operation forklifts are involved because parts are sent on pallets. After unloading, parts are placed into tents for labelling. After that, parts are put-away to main building of logistic centre, also by forklifts. In logistic centre parts can be repacked into other type of packaging or sent to storage place. Repacking is aimed to simplify picking process as suppliers sent parts in big packaging units, but demand from production units is in small quantities.

Storage place consists of metal racks where different type of packaging can be stored. The parts are stored in plastic boxes and wooden pallets, where special areas are dedicated for them.

Picking is one of the most costly process where much labour work is needed. Picking is executed by forklift drivers which collect parts according to a picking list.

After picking, parts are sent directly to production units assembly lines by wagons.

If parts go through logistic centre, these is no more need to handle packaging in logistics processes in Chassis Assembly as parts directly go to assembly line (figure 15).

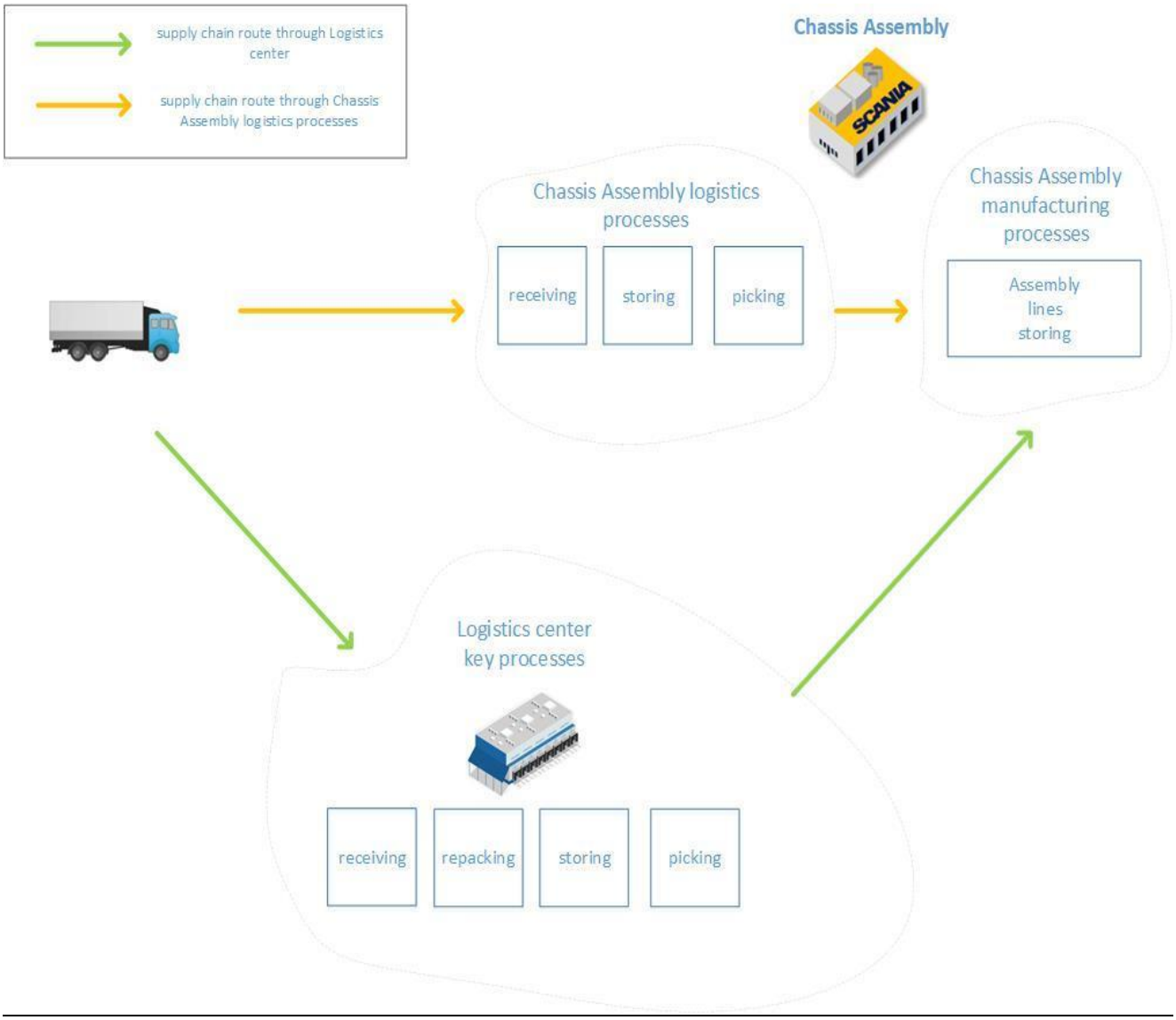


Figure 15 Material flow between Chassis Assembly, Chassis logistics and LC

4.10 Transportation network

Scania has multiple suppliers from all over the world and parts are delivered mainly by trucks as the key physical flow is from Europe where road infrastructure provides fast delivery and flexibility in order arrival . It has been chosen to describe the transportation network of the European region (see figure 16).

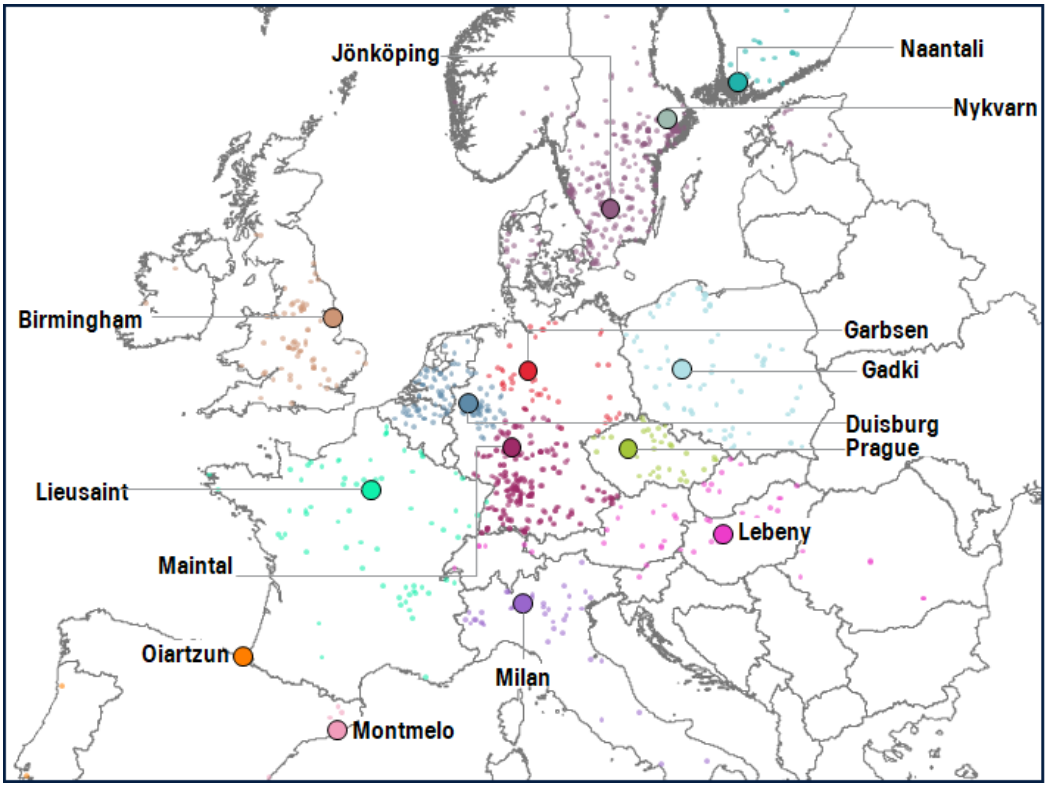


Figure 16 Map of Scania X-Docks

The transportation network consists of truck which delivers packaging filled with parts to depots called X-docks at Scania. Trucks are loaded at supplier's site and then they deliver packaging to X-dock or to PRU or logistic centre. The variance of track's routs is because of the initial fill rate at supplier's site.

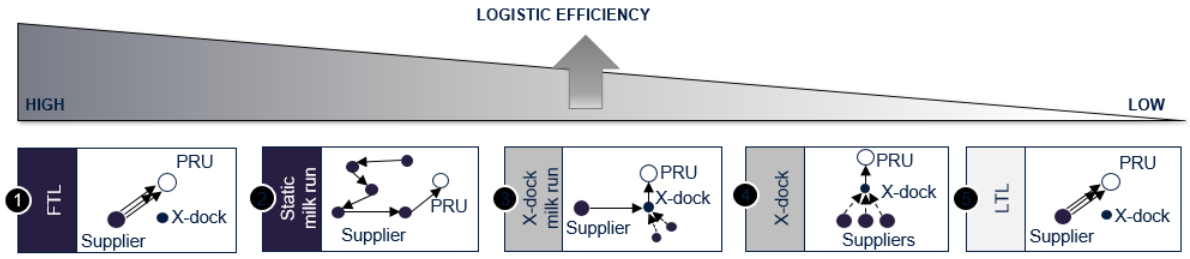


Figure 17 Logistic efficiency at Scania

Figure 17 shows how fill rate influences logistic efficiency and way of transport.

If there is full truck load, parts are directly sent to Scania and there is no need of consolidation of different shipments.

Static milk run means that trucks go through several suppliers to get full load and then moves to PRUs.

Next type of delivering is when X-dock is involved in transportation process. Some number of trucks collect parts from several suppliers and unload parts at X-dock where they are consolidated to certain PRU and after that another truck with full load delivers parts to Scania site.

Another type of distribution is similar to previous one as X-docks is part of it but the difference is that all suppliers have low loading rate. Parts are also consolidated and are sent out to PRUs.

And the last way of delivering is without X-dock where parts are sent with low fill rate. Logistic efficiency directly influence carbon dioxide emissions and costs that is always wanted to be reduced. Fill rate is a clear indicator of transportation performance.

Department OI at Scania is responsible for making routes for different suppliers, optimizing network and working with 3PL providers. Their task is to reduce costs, increase reliability and delivery time. Scania has its own transportation infrastructure and also deals with external transportation providers such as DHL, DSV and Schenker.

5 Selection of cost objects

This Master thesis includes quantitative studies based on cost calculation. The project needs to select cost objects and this chapter describes the selection process.

5.1 Selection of cost objects

List of MHs is too long in Scania's packaging system. To answer research questions packaging have to be matched with costs and as this project has a time limitation, list of studied packaging will be prioritized according to usage in handling of parts. Usage in this thesis will be based on volume as it reflects real turnover and physical presence in supply chain. Tracking by quantities does not show popularity of packages as their size varies a lot. The number of handled packages does not reflect actual situation as packages can be small as a box or big as a palle.t

Total delivered volume of the 237 standard and special empty MH to suppliers from Vida packaging pool for the period of 6 months (2017.09.01-2018.02.28) is 211 271 m³. 23 MHs were selected as objects of thesis scope after careful analysis of supply statistics between the SC actors. The total volume of these selected MHs is 147 890 m³ which is more than two thirds of the entire volume sent. Selection of these MHs among all the packaging system sent consisted of three steps (See figure 18).

Step 1 - Sort suppliers according to the total volume of empty MHs received.

Step 2 - Choose top, mid and low volume suppliers from step 1 data (15 each).

Step 3 - Select all the common MHs used by these suppliers from step 2.

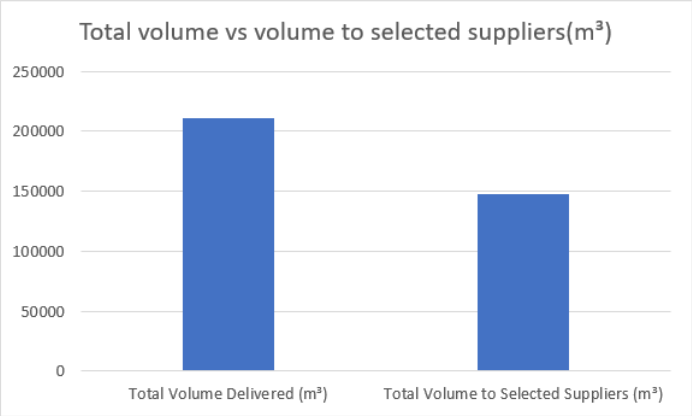


Figure 18 Total volume and volume to selected suppliers

The MHs selected previously are used by 70% of suppliers. Based on selected MH, it can be easily understood what type of packages are used more in turnover. So the study of activities and analysis related to these packages can be considered generalized to all the packages with the exception of special packaging. The figure 19 shows the distribution of different MHs of top 9 standard MHs with respect to the volume. The other 2 MH are special packaging for low volume suppliers that is not included in the pie chart because the share of these MHs are very low compared to selected standard packaging.

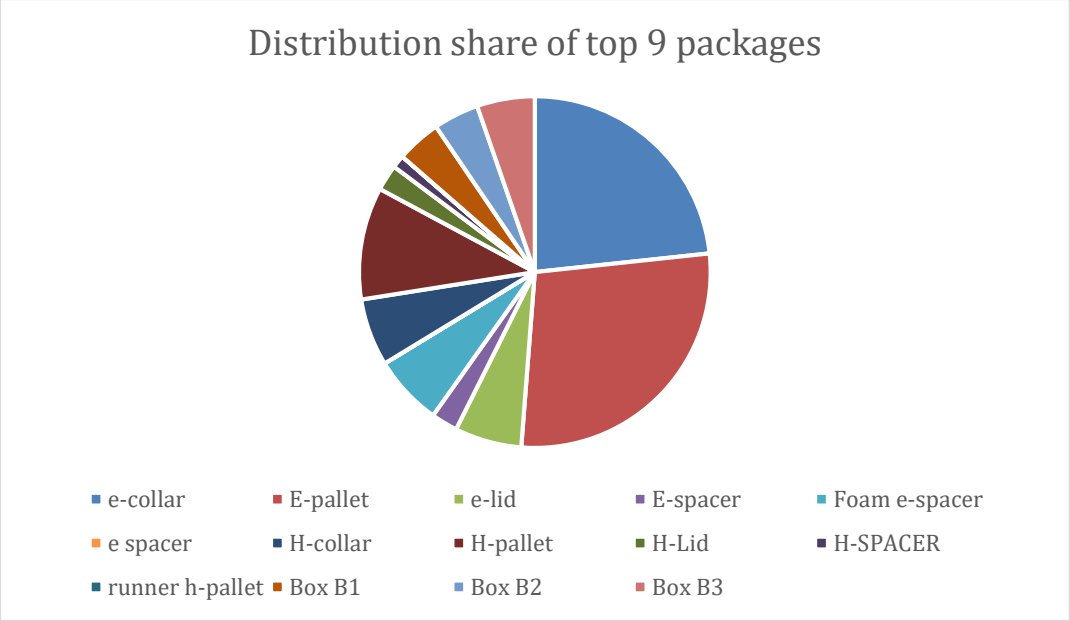


Figure 19 Distribution of packaging material

From the pie chart it is evident that E-pallet and H-pallets are two MH that are used extensively. The volume of these two pallets are close to 25% of the entire volume of empty packages delivered. Additional MHs such as collars, lids, foam spacers, 3 types of boxes are used to great extent in the packaging assortment as well.

All these 23 MHs are used for building 8 packaging which handle parts from suppliers to Scania production units. As mentioned before, after breaking down packaging to MHs, they are delivered to suppliers by creating distribution units meaning one set of MH are sent on H-pallet or E-pallet. For this investigation 8 packaging are the costs objects.

6 Supply chain cost estimation system

In this section the identified resources, resource drivers, activities, cost drivers and cost object parts will be presented.

Once the scope of the packaging and supply chain actors were identified it was decided to create a model that provides a cost estimation applying ABC costing method. As explained previously ABC costing method will provide costs for a particular packaging respective to the supply chain actor.

First step was to identify the main processes at each supply chain actors related to packaging and later brake down those processes into activities to be able to calculate the costs for each particular packaging respective to that particular activity which will in future provide the answer to the research questions. Most of these processes and activities were identified after visiting supply chain actor's facilities and their key managers.

6.1 Cost elements

To build a cost model of the packaging supply chain there must be a clear understanding of how supply chain actors are broken down to processes and activities. Looking a bit further into detail in processes it is meaningful to split them up to activities and each of these activities have spending on its execution. All activities of the SC actor's processes can be found in Appendix B-G. Resources are an important component of the cost model as they account for spending and are required to complete activities. Resources should be identified and they can be varied according to processes. All cost calculations are built on spending on resources.

Current cost model does not include capital costs as the range of Scania parts are extremely wide and there is no possibility to consider all of them. This model focuses on spending only on packaging.

6.2 Resources identification

For all activities three resources were identified in total. These are forklifts, space and labor (F, S, L). Administration work is not included in that model as it is too complex to understand how administrators distribute time for particular packaging.

Activities for all supply chain actors are quite common but have some differences. List of all unique activities and resources needed for completing them can be find in activity Relation (RAR) matrix (Table 6). In the matrix (see table 6), relations between the activities and resources are marked out with a cross symbol. The relations signals that the activity in question actually consumes the related resource.

Activities/Resources	Forklift	Space	Labor
Receiving	x		x
Storing		x	
Building assortment			x
Loading	x		x
Put-away	x		x
Box registration			x
Picking	x		x
Labelling			x
Inspection			x
Unpalletizing			x
Packaging break down			x
Pallets strapping	x		x
Box washing			x
Material sorting		x	x
Transportation	x		

Table 6 Resource - Activity Relation matrix

Table X shows that for most of the activities labor is required as packaging should be handled, moved and sorted. Resources such as space plays main role in warehouses and in sorting. Forklift is also used in many activities in order to move pallets from one place to another. Pallets are too heavy to just apply manual work.

6.3 Resource drivers

For each resource a belonging resource driver was identified that intends to describe the consumption of that resource. Resource driver usually is a number or percentage of some resource.

The resources that shared the same resource driver with more than one process are split up to several rows in ABC tables in Appendix. In an example of loading and unloading activities the same forklift and forklift driver are involved but its share of time is different. Resource drivers are measured in number of laborers, forklifts, picking and storage locations.

List of resources and its resource driver can be found in table 7.

Recources	Resource drivers
Forklift	# of forklifts
Labor	# or % of labor
Storage space	m2

Table 7 Lists of resources and its drivers

6.4 Accounting cost objects

After all activities, resources and resource drivers are identified and matched cost objects can be reached. To calculate costs, spending on resources must be gathered and from reliable sources. Spending on laborer's salaries were taken from Scania financial department and considered average salary in Sweden (42628.5 SEK per month in 2018)[1]. All salaries costs are presented before taxes.

Forklifts are varied based on processes where they can be diesel, electric and have different maximum loading weight. This means that forklift costs should be studied more deeply, matching the type with each process individually.

Last type of costs are on space. Most of the space required for packaging relates to Scania area with exception being packaging pool Vida and supplier sites. Scania rents land through a subsidiary of Scania and price is calculated by 1 m^2 per year. Price of rent depends on infrastructure of land considering such factors such as type of construction, heating and type of roof.

When costs for activities and processes are obtained, next step is to break them down to different types of packaging. There are eight packages which appear as cost objects. To divide costs on resources to packages observations were applied, using the methods of interviews, time measurements and analysis of turnover. Some of the processes are dedicated only for particular packages and it is easier to figure out costs for objects. When resources are distributed for handling more than one packaging in an example of unloading pallets and boxes, it can be considered that boxes are always received on that pallets and costs of receiving pallet are divided to the number of boxes on it.

Number of boxes depends on the type of boxes as B1, B2, B3, SM and MB. Table 8 shows average number of boxes on H pallet in respect of its type.

Type of box	Number of pcs
B1	16
B2	8
B3	4
SB	8
MB	8

Table 8 Average number of boxes on H-pallet

In some activities such as storing, costs are calculated based on needed area for racks and how many packaging units can be placed. For some packages such as E-pallet and H-pallet storage places for any location is the same in spite of sizes of that packages are different.

With exception of transport costs calculations, costs for each packaging unit was calculated by a common equation:

$$\boldsymbol{Costs} = \boldsymbol{x} \times \boldsymbol{S} + \boldsymbol{y} \times \boldsymbol{F} + \boldsymbol{z} \times \boldsymbol{L} \quad (1.1)$$

Where x, y and z resource drivers for the resources Space, Forklift and Labour.

[1] https://www.averagesalarysurvey.com/sweden

Cost of transportation was taken as average from annual internal report of Scania where it was stated that to deliver 1 ton of packages costed around 450 SEK. Costs for this project considered the weight of each object.

The weight for each packaging was received from an internal Scania data base. The equation used to calculate transportation costs:

$$Transport\ costs\ for\ packaging\ unit = wt \times 450 \quad (1.2)$$

Where *wt* is weight of packaging in tons.

All costs for each packaging per all supply chain actors and their activities can be found in Appendix B-G. The tables include several columns which show information about resources, resource drivers, packaging and costs objects for each activities.

All calculations were made by using excel and all results were delivered to tables.

6.5. Results of cost objects from ABC method

When all costs were calculated, it was grouped by SC actor and packaging unit. Table 9 shows results of cost objects. All numbers are given SEK meaning how much it costs to handle each type of one piece of packaging through every SC actor.

Cost objects	Supplier	Inbound	Logistic centre	Chassis Assembly	Breakdown	Pool VIDA	Outbound
E-pallet	26.24	26.12	33.50	25.08	43.54	12.18	18.84
H-pallet	20.89	16.56	32.93	24.29	36.63	11.91	10.89
B1	1.62	0.77	5.13	17.08	0.08	9.14	0.31
B2	2.80	1.51	7.04	17.62	0.16	9.55	0.56
B3	5.16	2.86	10.87	18.52	0.33	9.55	1.04
MiniBox	2.80	1.69	7.04	17.62	0.13	9.04	0.93
Small Box	2.80	3.16	7.04	17.62	0.13	9.23	1.45

Table 9 Results of ABC

It can be seen that costs on E-pallet and H-pallet are much higher than on boxes. The main reason for this variation is because of the different sizes of packages and their weight. Comparing costs of SC actors, it is observed that there is a huge difference between Breakdown and pool VIDA. This can be explained by VIDA having more automated operations with less number of laborers. In addition, Breakdown just unloads and loads boxes from one means of transport to another other. Outbound transportation is cheaper than inbound for all objects as it can provide better fill rate. Logistic centre is more efficient to handle boxes than Chassis Assembly due to racks being higher and more units are placed on 1 m^2.

7 Influence of packaging options on supply chain costs

This chapter presents of two scenarios of changes in packaging system in order to understand how supply costs are changed.

The current packaging system of Scania is developed over many years but there are always changes because of new specifications of parts and demand from logistics.

After understanding current packaging system and its costs in the supply chain, next step is to identify how different packaging options will affect supply chain costs. There are several ways to do it, but in this thesis the most suitable approach will be "Scenarios" meaning what will happen if Scania introduces a new part or decides to replace all wooden pallets with plastic. Each Scenario influences inputs for ABC especially on resources and its drivers.

7.1 Scenario 1: Introduction of new part

To test how packaging system and costs will vary, Scania assumes that there is need to handle new part in SC. This part is absolutely new and it is addition to current list of parts. All parts have to be packed in returnable packaging with pallets, collars and other materials. This scenario is based on comparison between two methods of packing that part. The first one is to use current packaging materials including one of the spacers. The second one is when Scania uses current packaging materials but with implementing new spacer.

In order to compare two cases, results of ABC will be used as they are good reflection of how operations work and how much money is needed to handle the spacer.

The key difference in two methods of packing is that new spacer has better fill rate which means that Scania can use a smaller number of packaging to handle the same number of parts. That gives reduction in costs associated with volume because of less spending on handling quantities of packages.

But at the same time, a new spacer creates additional costs at different supply chain sites as operations are becoming more complex. The changes in operations will increase costs in Breakdown and in packaging pool Vida. Breakdown has to expand additional space for sorting and temporary storage which will cost 11 SEK per day. That value is built on the price of renting space in Södertälje for industrial purposes. Pool Vida will just have additional space for storing and it will cost 27,9 SEK per day. One more supply chain actor who will be affected by implementing new spacer are suppliers. They also have to pay for additional space for storing new spacer and it accounts 4.45 SEK per day.

To compare two ways of handling a new part, ABC method must be updated where it will show how costs change according to each option.

Firstly, results from ABC are gathered with new inputs from first case and with new inputs from the second one. Then those two results are part of calculations of total cost for each case considering

turnover of packages. It is important to note that the second case has less turnover than other because of better fill rate of parts. After that, these total costs are compared with each other showing total savings and static costs for adding a new spacer. This scenario has various options in packaging and final result of comparison depends on inputs.

To get different results from this Scenario, Excel tool was developed in order to change inputs for both of the cases. Such inputs can have different values for fill rate, volume of new part and what type of pallet will be used. Framework of excel tool is the result of ABC which has all cost objects. Excel tool gathers previous results and change them according to new inputs.

Input		
Parts per year	**10000**	parts
packaging type	**E-pallet with collars**	packaging unit
parts with current spacer	**15**	parts/pallet
parts with new spacer	**20**	parts/pallet
Results		
Static costs for adding 1 MH	8736.5925	SEK
Total savings:	241395.9271	SEK

Figure 20 Excel tool for comparing packaging options

Figure 20 shows how excel tool works and that grey cells are inputs which are changed. That figure has inputs which look realistic if Scania introduces new part. All results are given per year.

From the figure x it can be seen that if fill rate is increasing from 15 parts to 20 per pallet, savings per year is about 241395 SEK. With increasing fill rate, savings are always higher. Static costs are on the same level which are sum of additional costs at breakdown, suppliers site and packaging pool VIDA.

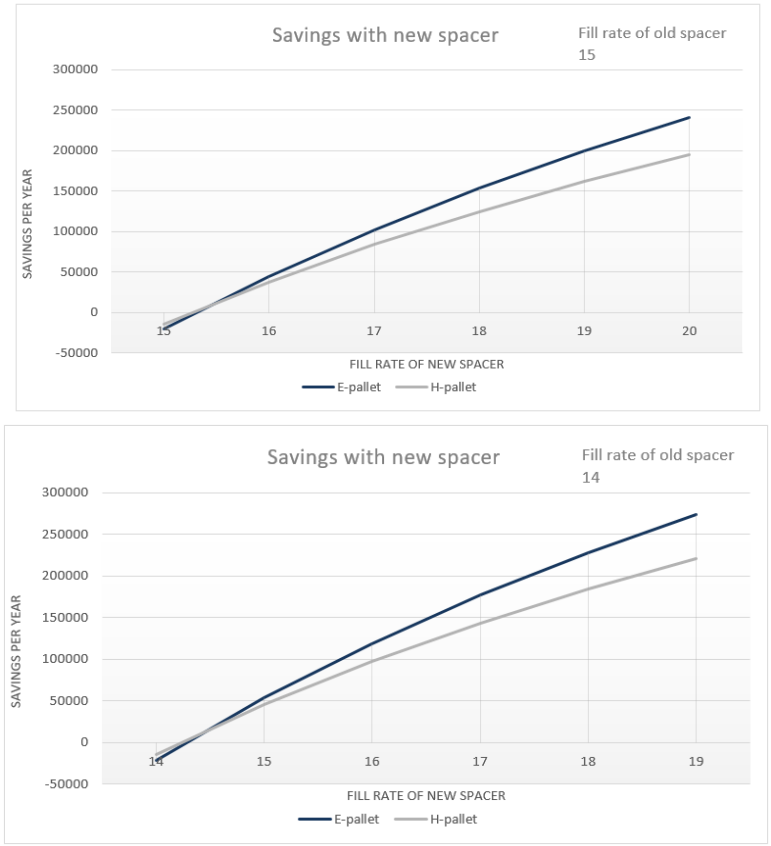


Figure 21 Results from excel tool

Figure 21-22 shows different results from excel tool where inputs are changed. To test tool and realize how costs are affected according to packaging option of E-pallet or H-pallet. Secondly, graph includes how savings varies according to the better fill rate of new spacer. All four graphs differ from each other with initial fill rate of current spacer.

An example from the second graph (which has value of current spacer as fourteen). Then the model compares total costs when old spacer is used with total costs when new spacer is introduced with the same or better fill rate. It can be seen from all graphs that if fill rate of new spacer is the same as current one, Scania will have negative savings because of additional costs in operations but without any increase in efficiency. By increasing the fill rate even by 1 piece the savings are going up.

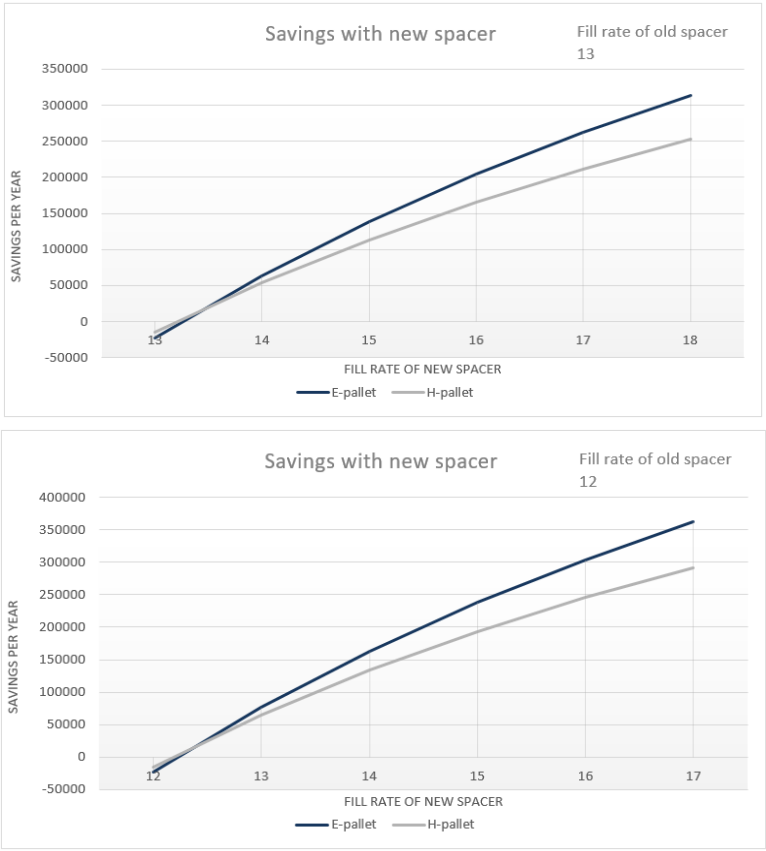


Figure 22 Results from excel tool

7.2 Scenario 2: Replacing wooden pallets with plastic

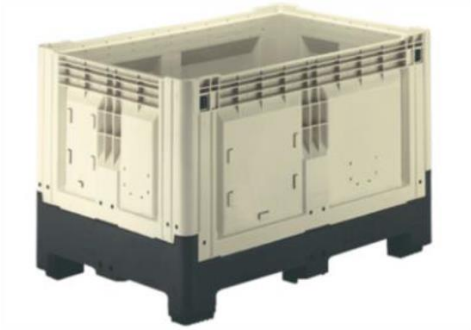
During many years Scania has been discussing implementation of plastic pallets but huge investments appears an obstacle. In this thesis, the full replacement of wooden pallets with plastic are described with a costs approach.

Plastic pallets have benefits comparing with wooden as they have less weight, purchasing cost and they have better weather-resistance. The main disadvantage of plastic pallets is that they use more from the environment and are more difficult to recycle as they are not produced from a natural resource.

Weight is one of the key criteria when cost are calculated and in this project all information about weight of packages are given and the average cost of transportation of 1 ton is known, it is easier to understand how plastic pallets can save spending in logistics.

There are a lot of suppliers who are ready to provide to Scania plastic pallets with various specifications of quality, dimensions and timelines. Plastic pallets have to be the same structure with collars and lids. From picture 9 it can be seen that the plastic pallet has collars that are not removed and that they are only folded, meaning that Breakdown has to change operations, reducing amount of labor. The need of labor will be less than nowadays, as packaging materials need not be broken down and picking will be

executed by solid folded plastic pallet without spending time on finding places of every packaging material.



Picture 10 Plastic pallet

The greatest influence of a plastic pallet is on transportation. Currently, weight is the limitation for maximum fill rate.

Characteristics	Wooden pallet	Plastic pallet
Dimension of an Assortment	1200*800*800	1200*800*800
Dimension of Pallet	1200*800*150	1200*800*140
Volume of an assortment(m3)	0,768	0,768
Volume when empty (m3)	0,24	0,28
Total weight (kg)	63,2	43,5
Cost of inflow (sek)	28,8	19,9
Cost of outflow (sek)	19,9	13,7

Table 10 Plastic and wooden pallet characteristics

From table 10 can be seen that total weight of two pallets quite different and one plastic pallet can save slightly less than 20 kilograms.

To estimate the packaging system and see how new packaging option influence cost, there will be an assumption that Scania is planning to introduce a new part and for its handling pallets must be used. Comparison will be for two pallets, plastic and wooden one.

The initial data for that case is 5000 parts per year and the capacity of one pallet is fifteen parts. To deliver parts to PRU and send out empty packaging back to suppliers, 334 pallets are needed.

The cost to deliver 1 ton of packaging costs 450 SEK meaning that spending on one wooden pallet is (0,0642 t) x (450) = 28,8.

314 SEK is the cost to send 1 ton of packaging back to suppliers.
Converting it to costs looks like this (0,0632 t) x (314) = 19,9. In the same way, costs of plastic pallet was achieved.

Value of inbound for plastic pallet is 19,9 and 13,7 for outbound. Now, obtained values are applied with the number of pallets needed for 5000 parts.

For wooden pallets total costs are 16195 SEK and for plastic 11222 SEK. It is obvious that savings by using plastic pallet is more than 5000 SEK just for 334 pallets. The whole packaging system of Scania is based on pallets and full replacement of wooden material will reduce operational costs especially in transportation.

7.3 Discussion

When two scenarios were presented and results showed that packaging options can affect cost, it is important to highlight the role of packaging in SC and especially in Scania.

First scenario was assigned to see how two options affect costs and what is more efficient. Creating a new spacer gives more benefits than using the old one as fill rate is a key factor of any packaging. Katrin and Pålsson (2016) in their article explain that it is important for the packaging to contributes to minimization of transportation along the supply chain and this can be achieved by increasing the fill rate in all levels of packaging system. Project results express that filling more products into packaging save space in storage and transportation cost. Both sites have high spending and even a small increasing of efficiency gives reduction of costs. Implementing of new MH requires time and money for its development but in the future it will give an outcome of costs reduction. A lot of industries in our days are trying be more flexible in services or in products which makes them develop new materials which leads to bigger income and savings (Chopra & Meindl, 2013).

Second scenario is quite popular as many companies discusses introducing of plastic pallets (Klimko, 2015). Scania as a company with deep values of continuous improvements also takes into consideration this trend. This master thesis shows in an example how plastic pallets can give benefit to Scania.

Plastic pallets mostly give savings in transportation because of total weight reduction. Today Scania does not have full volume load into trucks as there is weight limitations and plastic pallets will help this problem and it will be possible to load more parts in one truck. Nowadays, there is no clear investigation of time cycle of plastic pallets comparing with wooden ones. Some of wooden pallets are still in turnover after their launching in logistics using. The main barrier of setting up plastic pallets is huge investments as Scania's turnover is very high. Other companies, that are smaller than Scania can more easily introduce new plastic pallets and will have less work in adapting operations to new packaging types.

The outcome of this research gives a better understanding of the packaging process throughout the supply chain. It shows that packaging affects costs and any changes in its assortment leads to costs increasing or reducing.

The cost model relates packaging to various operations and applied Activity based costing appears as a useful tool not only for calculating of costs of goods sold (COGS). It has been able to gather all data needed for getting correct costs related to any objective in a supply chain. This work is a good example of how to calculate packaging costs, evaluate the packaging system of an industrial company. Pålsson et al. (2011) describe different evaluation models related to packaging considering environmental and

costs factors. This work has taken into consideration economical aspects of returnable packaging in order to give readers insight into influence on costs in a supply chain.

Industries especially automotive companies have to consider cost drivers of returnable packaging even before its implementation. The business environment is changing and new parts are introduced that makes logistics create new packaging or make a decision of choosing the right one from the current assortment.

Scania will use result of this Master thesis and consider it when introducing new packaging or eliminating existing ones. With this project it becomes possible to see all affected sits of changes of packaging and know the difference in supply chain actors operations.

8 Results and conclusion

This chapter presents the results of this master thesis project and all research questions are answered.

After careful literature review, it was concluded that different authors explored topics concerning packaging. They worked on one-way or returnable packaging in various industries including automotive. Main evaluation criteria were environmental and economical aspects. This thesis focused on costs related to packaging activities. The project had a practical nature as a case study of an automotive company with a specific packaging assortment and supply chain. Literature study provided knowledge about logistics, supply chain management and costing methods. It helped to develop way and approach for building empirics and creating a model which answers all research questions.

In the thesis, review of literature on logistics and supply chain management was made explaining which are the main processes, inputs and outputs and how a supply chain can be structured. Theory of packaging gave a wide overview of its function, how it is used in SC and why returnable packaging exist. As the study focused on supply chain, packaging and its costs, the main instrument of connecting these three areas was Activity based Costing method. In the theory section it was introduced and its approach was described, how it works and what should be included in calculations.

Before applying ABC in this project, all activities were identified at Scania packaging supply chain describing all operations and industrial facilities.

To estimate packaging cost system, ABC was used where identified activities were matched with resources for completing those activities. Resources were translated to costs and grouped per activity and per type of packaging. Using this method, it was quite clear to understand where spending is higher or lower. Such a method opened up opportunities to see how changes in the packaging system influence SC and its costs. Different packaging options have effects on resources needed to handle returnable packages. Output of changes in costs are provided by the excel tool (which gathers results from ABC) and allowing adapting resources to a new packaging assortment.

The main purpose of this thesis was tackled and four research questions were successful reached results which are presented in detail in following paragraphs.

- *What type of costs in the supply chain will be affected if the size of the packaging assortment is changed?*

After testing Scania packaging system by two scenarios, it was noted that changes in packaging influence more on transportation costs and on costs for renting additional space at storage. A new spacer creates demand for storage area as all packaging material are stored separately at pool Vida and at supplier site.

- *How does packaging influence on overall supply chain cost in transportation, warehousing and material handling?*

Spending on packaging costs through supply chain are quite high and they are distributed on seven SC actors. The highest costs has BreakDown as they use a lot of manual work and its turnover is high as well. Logistic centre is the most efficient which makes their costs lower than other actors. Chassis Assembly also doesn't perform well according to observations and data analysis. Their costs a bit less than at Breakdown. Inbound and outbound transportation have differences in costs, as sending packaging back to suppliers takes less space and fill rate in truck is higher. Table of SC costs can be found in Appendix.

- *Who are the most affected actors and activities in the supply chain if the size of the packaging assortment is increased or decreased?*

Two scenarios showed how packaging options influence on SC and its activities. That method of assumption of introducing new spacer or replacing wooden pallet to plastics reflects who are the most affected actors. Packaging pool VIDA, Breakdown and suppliers are affected actors if Scania introduces new packaging material. Resources such as space should be added for sorting and storage.

If Scania replaces wooden pallets to plastic, such SC actors as Breakdown, pool Vida and transportation are affected. Load on transportation will be less because less total weight, Breakdown and Vida have to redesign operation as some variants of plastic pallets cannot be broken down to several materials. After plastic pallets are emptied at production site, they should be folded and sent to pool Vida.

- *Which are the characteristics of packaging assortment that will impact the costs in the supply chain?*

Activity based costing presented that resources are one of the main element in cost estimations system. Scania spends money on resources which are needed to complete activities in packaging handling. If packages characteristics are changed, resources also need to be updated. Characteristics of packaging assortment which play role of designing and planning operations are weight, kind of material, and how packaging consists of various materials.

In conclusion, it can be noted that Excel tool was developed and will be used in future projects in Scania packaging and in daily business. This tool is able to be updated to the specific user's requirement of the various stakeholders from SC.

Scenarios showed that there is opportunity to potential optimization in logistics and packaging. New spacers for new part can save spending and reduce emissions.

Plastic pallets are becoming a new trend in logistics as they have less weight that means less costs. Introducing plastic pallets requires high investments as Scania has a huge number of packaging in turnover. Partly replacing pallets makes supply chain operations work with more complexity and adapt their work to one more packaging flow.

Generally, it can be concluded that the packaging system can be optimized and should be periodically reviewed as company always develops, new parts are implemented and competition increases.

Theory gave considerable understanding of packaging logistics and opportunity to apply theory in practice. Literature review was able to direct work towards the right path and create a base on how to relate packaging with costs.

Empirical studies was gathered by good understanding of theory and the what kind of data that must be gathered. Empirics was developed and analysis was conducted to answer all research questions.

This study had time and geography limitations but it created useful framework for future studies inside Scania which operates even outside Europe and also for whole automotive industry. New parts are continuously introduced and are needed to be packed according to Scania requirements. There are a lot of other SC in automotive industry especially MAN which is also part of Volkswagen Group. With that alliance it is possible to make collaboration between Scania and MAN and use common logistics infrastructure for mutual gain. This thesis showed that there are supply chain actors which have own logistics infrastructure assigned for returnable packaging but all of them can be investigated deeper with simulations and calculations in order to eliminate waste and reduce unnecessary work.

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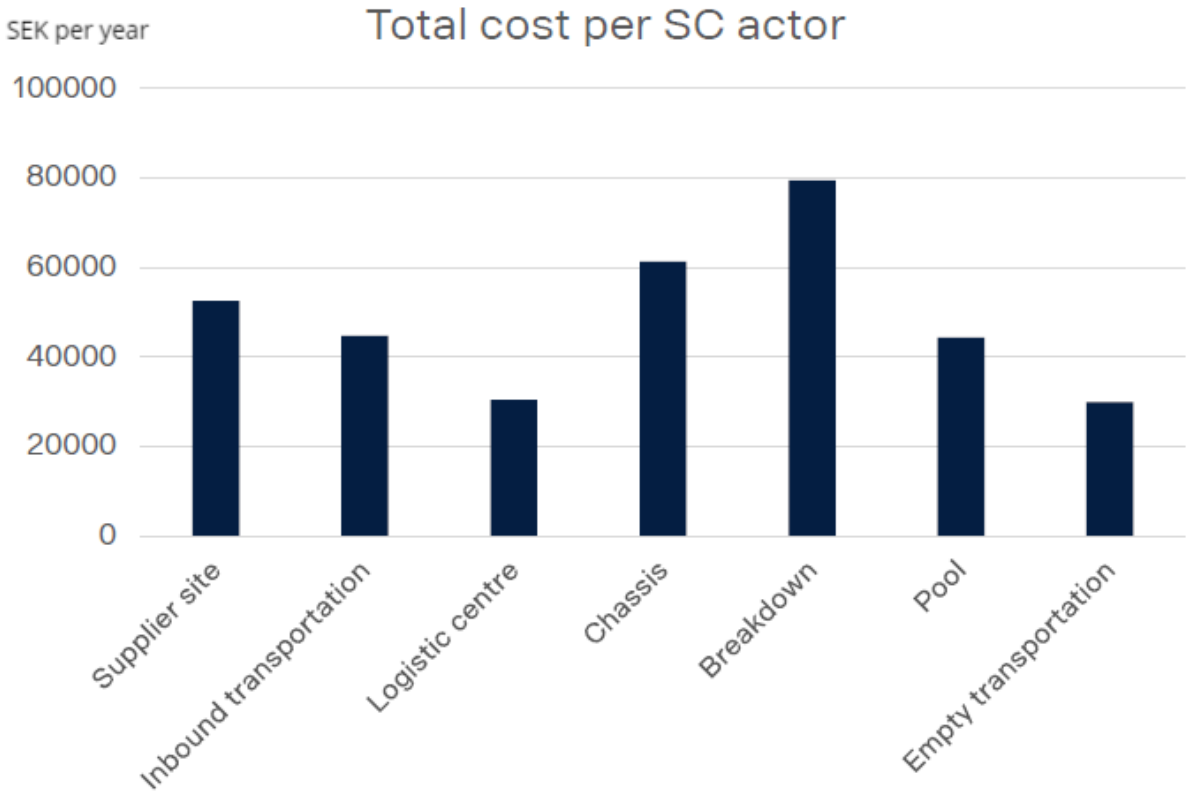
Appendix

a)



Costs per year for each SC actor.

b) Activity based costing for suppliers

Activity	Resources	Resource drivers	Packaging material Unit	Cost objects(SEK)
Receiving	Forklift driver, forklift	Time	E-pallet	1.34
			H-pallet	0.97
			B1	0.20
			B2	0.39
			B3	0.79
			MB	0.39

			SB	0.39
Storage(PP)	Racks or Floor	Area	E-pallet	0.95
			H-pallet	0.34
			B1	0.07
			B2	0.14
			B3	0.28
			MB	0.14
			SB	0.14
Buliding Assortment	Labour personnel	Time	E-pallet	13.22
			H-pallet	11.06
			B1	0.82
			B2	1.20
			B3	1.96
			MB	1.20
			SB	1.20
Storage(EP)	Racks or Floor	Area	E-pallet	4.45
			H-pallet	2.22
			B1	0.14
			B2	0.28
			B3	0.56
			MB	0.28
			SB	0.28
Loading	Forklift driver, forklift	Time	E-pallet	6.29
			H-pallet	6.29
			B1	0.39
			B2	0.79
			B3	1.57
			MB	0.79
			SB	0.79

c) Activity based costing inbound trasnportation

Activities	**Resources**	**Resource drivers**	**Packaging material Unit**	**Cost objects**
Transportation	Own Transport solution or 3pl	Weight	E-pallet with collar(10-16)	*26.12*
			H-pallet with collar(20-26)	*16.56*

			H-pallet with boxes	*13.15*
			B1	*0.77*
			B2	*1.51*
			B3	*2.86*
			B4	*2.12*
			SB	*3.16*
			MB	*1.69*

d) Activity based costing for Chassis Assembly

Receiving

Activities	Resources	Resource drivers	Packaging material Unit	Cost objects
Unloading incoming goods	Forklift driver, forklift	3,6 forklift drivers, 2 forklifts	E-pallet	*4.04*
			H-pallet	*4.04*
			B1	*0.25*
			B2	*0.51*
			B3	*1.01*
			MiniBox	*0.51*
			Small Box	*0.51*
			T-pallet	*4.04*
Labelling	Labour personnel, labels	2 labour	E-pallet	*2.30*
			H-pallet	*2.30*
			T-pallet	*2.30*
Loading outgoing packaging units	Forklift driver, forklift	2 forklift drivers, 2 forklift(exclude 231 STORAGE)	E-pallet	*4.90*
			H-pallet	*4.90*
			T-pallet	*4.90*
Put-away of packaging unit to storage	Forklift driver, Forklift, Scanning device	4 forklift drivers, 2 forklifts (231TS, 231GMT,231GMS)	E-pallet	*11.80*
			H-pallet	*11.80*
			T-pallet	*11.80*

Pallet Storage 237s

Activities	Resources	Resource drivers	Packaging	Cost
Unloading incoming pallets	Forklift driver,forklift	25% of 1 forklift driver, 25% of 1 forklift	E-pallet	*2.18*
			H-pallet	*2.18*
			T-pallet	*2.18*
Inspection	Forklift driver	5% of 1 forklift driver	E-pallet	*0.44*
			H-pallet	*0.44*
			T-pallet	*0.44*
Put-away incoming pallets	Forklift driver, Forklift	70% of 1 forklift driver, 70% of 1 forklift	E-pallet	*6.09*
			H-pallet	*6.09*
			T-pallet	*6.09*
storage	Storage space(racks or floor)	1299 of storage locations, m2	E-pallet	*1.15*
			H-pallet	*1.15*
			T-pallet	*2.31*
Picking	Forklift driver, Forklift	60% of 1 forklift driver, 60% of 1 forklift	E-pallet	*5.87*
			H-pallet	*5.87*
			T-pallet	*5.87*
Labelling	Forklift driver	10% of 1 forklift driver	E-pallet	*0.79*
			H-pallet	*0.79*
			T-pallet	*0.79*
Deliver to 236	Forklift driver,forklift	30% of 1 forklift driver, 40% of 1 forklift	E-pallet	*2.94*
			H-pallet	*2.94*
			T-pallet	*2.94*
Interim storage	Storage space	m2	E-pallet	1.57
			H-pallet	0.78
			T-pallet	1.96

Box Storage

Activities	Resources	Resource drivers	Packaging material Unit	Cost objects
Unstrapping and lid removal	labour personnel	40% of labour	B1	*0.20*
			B2	*0.39*
			B3	*0.79*
			MiniBox	*0.39*
			Small Box	*0.39*
Empty box removal	Labour personnel	60% of labour	B1	*3.81*
			B2	*3.81*
			B3	*3.81*
			MiniBox	*3.81*
			Small Box	*3.81*
Unpalletizing	Labour personnel	400% of labour	B1	*2.86*
			B2	*2.86*
			B3	*2.86*
			MiniBox	*2.86*
			Small Box	*2.86*
Labelling	Labour personnel	100% of labour	B1	*1.43*
			B2	*1.43*
			B3	*1.43*
			MiniBox	*1.43*
			Small Box	*1.43*
Put-away	Forklift driver,Forklift	4 of forklift drivers,2 of forklifts	B1	*3.16*
			B2	*3.16*
			B3	*3.16*
			MiniBox	*3.16*
			Small Box	*3.16*
Storage	Storage space(box & pallet)	5904 storage locations	B1	*0.20*
		7882 storage locations	B2	*0.28*
			B3	*0.28*
			MiniBox	*0.28*
			Small Box	*0.28*
Picking and delivering	Forklift driver, forklifts	7 of forklift drivers, 7 of forklifts	B1	*5.17*
			B2	*5.17*
			B3	*5.17*
			MiniBox	*5.17*
			Small Box	*5.17*

Pallet Storage 231s

Activities	Resources	Resource drivers	Packaging	Cost
Picking, labelling and Put-away	4 Forklift drivers, 2 forklifts	8 Forklift drivers, 4 forklifts	E-pallet	*21.68*
			H-pallet	*21.68*
Storage	Storage space(racks)	3617 storage locations	E-pallet	*0.80*
			H-pallet	*0.80*

e) Activity based costing Breakdown

Receiving and Breakdown

Activities	Resources	Resource drivers	Packaging unit	Cost objects
Unloading	Forklift driver,forklift	6 forklift drivers,3 forklifts	E-pallet	*1.75*
			H-pallet	*1.75*
			B1	*0.03*
			B2	*0.05*
			B3	*0.11*
			MB	*0.04*
			SB	0.04
Put-away onto conveyer	Forklift driver,forklift	4 forklift drivers,2 forklifts	E-pallet	*1.67*
			H-pallet	*1.67*
Label removing	Labour personnel	4 labourers	E-pallet	*1.29*
			H-pallet	*1.29*
Collar removing	Labour personnel	6 labourers	Pallet	*2.09*
Additional packaging material	Labour	8 labourers	Pallet	*2.79*
Interim Storage 1	Rack orFloor Storage	105m2/24 locations	E-pallet	*11.45*
			H-pallet	*5.73*
Sorting and Storage	Racks	75m2/84 locations	Pallet	*2.34*
Bundling	Labour personnel	4 labourers	E-pallet	*2.04*
			H-pallet	*0.86*
Strapping	Labour personnel	2 labourer	E-pallet	*2.68*
			H-pallet	*2.68*
Put-away of pallets	Forklift driver, forklift	4 forklift drivers, 2 forklifts	E-pallet	*5.99*
			H-pallet	*5.99*

Shipping

Activities	Resources	Resource drivers	Packaging Unit	Cost objects
Loading (wagon cart)	Forklift driver,forklift	2 forklift driver,1 forklift	E-pallet	*3.00*
			H-pallet	*3.00*
Shipping	WC Driver,Wagon	1 Wagon,2 Driver	E-pallet	*2.99*
			H-pallet	*2.99*
Unloading	Forklift driver,forklift	2 forklift drivers,1 forklift	E-pallet	*2.19*
			H-pallet	*2.19*
			B1	*0.03*
			B2	*0.07*
			B3	*0.14*
			MB	*0.05*
			SB	*0.05*
Loading(truck)	Forklift driver,forklift	1 forklift driver,1 forklift	E-pallet	*1.28*
			H-pallet	*1.28*
			B1	*0.02*
			B2	*0.04*
			B3	*0.08*
			MB	*0.03*
			SB	*0.03*

f) Activity based costing for packaging pool VIDA

Receiving at box breakdown

Activities	Resources	Resource drivers	Packaging Unit	Cost objects
Unloading	Forklift, Forklift driver	1 forklift driver, 0.5 forklift	E Pallet	*7.62*
			B1	*0.12*
			B2	*0.19*
			B3	*0.19*
			B4	*0.10*
			MiniBox	*0.19*
			Small Box	*0.19*
Put-away on to conveyer	Forklift, Forklift driver	1 forklift driver, 0.5 forklift	E Pallet	*7.62*
			B1	*0.12*
			B2	*0.19*
			B3	*0.19*
			B4	*0.10*
			MiniBox	*0.19*
			Small Box	*0.19*

Breakdown 1 (Hall A)

Activities	Resources	Resource drivers	Packaging material Unit	Cost objects
Label, collar and additional packaging material removal	Labour personnel	4 labour personnel	B1	*0.82*
			B2	*0.82*
			B3	*0.82*
			B4	*0.82*
			MiniBox	*0.82*
			Small Box	*0.82*
Boxes disintegration	Labour personnel	3 labour personnel	B1	*0.61*
			B2	*0.61*
			B3	*0.61*
			B4	*0.61*
			MiniBox	*0.61*
			Small Box	*0.61*
placing boxes onto roller also pallets	Labour personnel	2 labour personnel	B1	*0.41*
			B2	*0.41*
			B3	*0.41*
			B4	*0.41*
			MiniBox	*0.41*
			Small Box	*0.41*
Washing	Labour personnel,Washing equipment	# of labour	B1	*5.50*
			B2	*5.50*
			B3	*5.50*
			B4	*5.50*
			MiniBox	*5.50*
			Small Box	*5.50*
Stacking boxes	Labour personnel	2.5 labour personnel	B1	*0.85*
			B2	*0.85*
			B3	*0.85*
			B4	*0.85*
			MiniBox	*0.85*
			Small Box	*0.85*
Put-away to interim storage	Forklift driver, Forklift,PJ and operator	1 of forklift drivers, 1 ofForklift, 1 of PJ operator	B1	*0.44*
			B2	*0.44*
			B3	*0.44*
			B4	*0.44*
			MiniBox	*0.44*
			Small Box	*0.44*

Receiveing at breakdown from 270(pallets without boxes)

Activities	Resources	Resource drivers	Packaging Unit	Cost objects
Unloading and put-away	Forklift driver, forklift	2,4 of forklift drivers; 1,2 forklifts	H-pallet	3.32
			E-Pallet	3.32

Storage

Activities	Resources	Resource drivers	Packaging Unit	Cost objects
Storing	Storage space(racks or floor)	# of storage locations	E-pallet	0.53
			H-pallet	0.27
			B1	0.01
			B2	0.01
			B3	0.01
			MB	0.01
			SB	0.01
Picking and Loading	Forklift driver, Forklifts	4,4 of forklifts, 8,80 of forklift drivers	E-pallet	8.32
			H-pallet	8.32
			B1	0.26
			B2	0.52
			B3	0.52
			MB	0.21
			SB	0.21

g)

Outbound transportation

Activity	Resources	Resource Drivers	Packaging Unit	Cost objects
Trnasportation	Own Transport solution or 3pl	Weight	E-pallet	18.84
			H-pallet	10.89
			B1	0.31
			B2	0.56
			B3	1.04
			B4	0.99
			SB	1.45
			MB	0.93