A Study on Packing Processes to Find Factors Influencing Fill Rate and Time Efficiency

Cross-case Analysis of Packing Processes for a Third Party Logistics Actor

Master's thesis in Supply Chain Management

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Summary

The increased globalization and growth of e-commerce has increased the complexity of distribution channels, leading to more companies hiring third party logistic (3PL) firms, such as DB Schenker, to manage the logistic part of the chain. This has led to a more competitive 3PL market, simultaneously with the increased environmental awareness in society, requiring outsourcing firms to offer both operational efficiency and sustainable solutions. With the transportation of goods being one of the main focuses in sustainable improvement, the packing of goods and the fill rate has become a growing interest.

The study was performed at DB Schenker's facility and focused on three customers, referred to as Customer A, B and C. The first step was to observe the activities performed at the packing stations, focusing on identifying issues while being provided with input from workers through unstructured interviews. This was pursued by efficiency measurements to confirm or neglect the problems formerly found. In addition, the fill rate in the different processes was evaluated with the help of secondary data from Schenker's own database. At last, complementary information was gathered if necessary through semi-structured interviews with group leaders. The findings was then analyzed to find correlations and differences, later leading to a discussion on the topic.

As a result from the study, a number of factors influencing fill rate and time efficiency was found. In addition to this, fill rate and efficiency correlated in a way where the efficiency decreased with increased fill rate. When focusing on fill rate, the main problem seems to be how the order constellations are set, as this often creates packages that needs additional activities performed such as repacking and cutting down boxes if boxes are not filled to a satisfactory level. Additionally, the adaptation of used load carriers to the products shipped affected both fill rate, where in cases with non-suitable load carriers the fill rate was found low, whereas using standardized boxes that does not require second thoughts by the packers decreased the time efficiency. The use of plastic bags in flows that allowed it to be used was also of interest, as these allowed for a fast packing process and did not affect the fill rate on a secondary level. Efficiency wise, the degree of standardization of work tasks seems to have a great effect. The flows having easier tasks, both with a standardized work process and load carriers, did not require workers to put effort in their tasks, but instead these could be performed on instinct, with a faster pace as a result.

At last it should be mentioned that the variety of flows showed to have an effect on fill rate and time efficiency. For the flows operating e-commerce and having multi- or omnichannels, additional requirements set by both Schenker's customers and end-customers

complicate the processes, adding activities to the processes performed at the packing stations. Foremost, this affected the standardization of order sizes and prevented demands set by Schenker towards customers that could simplify the flow of goods.

Keywords: Fill rate, Efficiency, Time efficiency, 3PL, 3PW, Outsourcing Logistics, Omnichannel

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Filip Kronvall Bjelkengren & Tim Maalsnes, Gothenburg, May 2020

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1 Introduction

This first chapter provides a brief description of omnichannels in the third-party logistic (3PL) industry and current challenges related to freight transport and how these influence the 3PL industry. Further it is explained how this affect the 3PL actor DB Schenker Logistics AB, from here on referred to as Schenker. Thereafter, the purpose of this thesis is presented. Finally, delimitation's to the project are shortly introduced.

1.1 Background

Environmental awareness is increasing around the world and climate protests are bigger and more frequent than ever (Taylor, Watts, & Barlett, 2019). Parallel to public protests, governments, companies, and related stakeholders are starting to realize the environmental importance of transportation and the impact transport emissions has on the environment (Demir, Huang, Scholts, & Van Woensel, 2015).

At the same time, the increased globalization during the last decades has driven the expansion of the global transportation system, and the freight transport market is expected to continue its growth. The global freight demand is projected to have tripled by the year of 2050 (ITF, 2019). According to McKinnon (2010) the need of transportation, and thereby also the emissions, can be reduced with higher vehicle utilization, which can be achieved by increasing the fill rate in the packages being transported.

Globalization and the expanding market create a competitive environment where companies constantly need to be active and develop their organization to meet customer demands (Parashkevova, 2007). The globalization also create an increasingly complex supply chain where goods has to be accessible from all parts of the world. A strategy many actors use to handle these problems is to focus on their core competencies and outsource all other activities. According to Arif and Jawab (2018), logistic operations are a common activity to outsource to reduce costs and let experts in the field handle the complex operations of a supply chain.

The growing e-commerce is further increasing the complexity of supply chains, as retailers have to combine their online and physical channels into one omnichannel (Hübner, Wollenburg, & Holzapfel, 2016). A channel is defined as an interaction point between the retailer and the customer, where omnichannels aims to provide the customer with a seamless experience with no difference whether they shop online or in store (Buldeo Rai, Verlinde, Macharis, Schoutteet, & Vanhaverbeke, 2019). The omnichannel increase the requirements on the supply chain operations since the same supply chain has to fulfill orders from both direct customers as well as from physical stores (Hübner, Wollenburg, & Holzapfel, 2016).

The increased outsourcing of logistics has created a big market for third-party logistic (3PL) companies and the 3PL industry is growing rapidly. In Sweden it grew from 7B

SEK in 2006 to 11B SEK in 2012, with the growth of 10% it is one of the fastest growing industries in the country (Hultén, 2018). Schenker, similarly to many 3PL companies, provides services such as warehousing, transportation, and value added services, e.g. packing and labeling. The operations a 3PL company handle range from simple operations, for instance stock keeping, to operate the customers whole supply chain (Arif and Jawab, 2018). The increasing market size has lead to increased competition among Swedish 3PL actors where many new actors are entering the market, thus pressuring large actors such as Schenker to continuously improving their operations. Especially when it comes to e-commerce, where the industry is exposed to price pressure, both from customers and competitors (Hultén, 2018).

To stay competitive, Schenker must handle the increased competition on the market while at the same time adjusting their operations to tackle the increased global pressure on environmental sustainability. It is therefore important that the existing processes are competitive both regarding operational efficiency and sustainability. The pick and pack process is one of the most important processes in warehousing, where picking is the biggest operational cost and has received a lot of attention by researchers (Kembro, Norrman, & Eriksson, 2018).

For Schenker, to achieve a high fill rate, the packing process is of great importance, and there has lately been a shift towards establishing effective packing processes to gain competitive advantage, especially with end-customers increased environmental awareness. However, it is important that the operational efficiency is preserved when increasing the fill rate to avoid sub-optimization, and to stay economically profitable through sustainable alternations.

1.2 Problem description

The main problem identified, that led up to the aim of the report, is the varying fill rates achieved in the packing processes at Schenker. As the company is working within third party logistics, the varying characteristics of packages handled within the operations creates a situation where a standardized way of working is not an option. Due to all companies having specific requests when it comes to the packing, it forces Schenker to act upon these requests which influences the processes. This increases the complexity of the operations and how to achieve high fill rates, thus being the focus of the project. Furthermore, as the company pay deliveries per collie, the fill rate in the packages will be of greatest importance, since a decreased amount of air shipped would result in fewer pallets being shipped. Additionally, the growth in online sales has created omnichannel flows, which in combination with customers becoming more aware of the importance of high fill rate, pressures 3PL companies to pursue better packing solutions and to adapt their processes to these flows.

It is also important to retain a high performing process that ensure monetary benefits for the company. For 3PL companies, the pressure is high to provide a flow that can cope with the new customers pace, and time efficiency becomes an important aspect to create profit for the focal company. In this case, to compare with the fill rates achieved in the different flows, the time efficiency for the processes will be measured and evaluated, to see how these two factors correlate.

1.3 Aim

The study aims to increase the understanding of the packing processes at Schenker to help identify related problems and to suggest improvements to increase fill rates in distributed parcels without negatively impacting time efficiency.

The following research questions have been formulated to fulfill the aim:

RQ1: *What are the main factors influencing fill rates in distributed parcels at DB Schenker?*

RQ2: *How do the main factors influence the overall time efficiency in the packing process?*

RQ3: *How could the identified factors in the packing processes be changed to increase the fill rate without decreasing time efficiency?*

1.4 Delimitations

The study performed will be focused on processes performed by Schenker at their facility, in cooperation with three customers, allowing the research to be conducted in depth, with focus on the selected companies to improve and evaluate these specific pick and pack processes. Possibly, the results from the study can be applied on other customers, however, the focus will be on these three main customers, thus not involving any input from other parties. Additionally, the study will focus on internal activities to improve in-house activities.

Furthermore, with Schenker handling several flows for each customer that are potential study objects, the project will be limited to study packing for e-commerce and stores for Customer B and C, whereas for Customer A, that does not have e-commerce, the packing for small and large orders will be studied. Other flows connected to the studied companies will not be considered, as they are not directly relevant to the project. This means that the focus will be on the activities performed at the packing stations connected to the packing of parcels. At last, the report will not go into depth how suggested improvements should be implemented.

2 Method

In this chapter, the course of action to find, select and explain a suitable methodology to fulfill the aim of the thesis is provided. This include defining a research approach, involving qualitative and quantitative methods to handle sets of data in a suitable manner. Furthermore, different research methods is to be used in the process of collecting data, and will be combined to create a complementary research methodology that utilizes advantages to decrease respective disadvantages. In addition, the structure of the research aims to reduce the impact of biases, and to create a reliable study leading up to a valid result.

2.1 Research Strategy

To gather data, both qualitative and quantitative research was conducted. This involved a literature study to deepen the knowledge in the topic area, and to enable a better understanding of the findings during the progression of the study. Apart from being consistently aware of bias, the collected data and theory used was evaluated to ensure its quality.

Quantitative research is often used when working deductively, and involves gathering numerical data to be compared with a formulated hypothesis based on existing theory and practice. This means that emphasis is directed towards conducting somewhat large amounts of data to create an objective view of the situation (Bryman, 2011). According to Muijs (2010), qualitative research is often, and will be in this project, based on interpretations of numerical data, to find correlations and patterns. Qualitative research is more focused on subjective factors, and is based on interpretations and constructionism. In contrary to quantitative research, a qualitative study uses the data gathered to formulate an hypothesis (Bryman & Bell, 2014). This way of gathering data is more situational, as it does not give a general but rather a contextual view in a specific environment. This makes the results applicable in the current study, however not necessarily in other, even though similar, contexts (Bryman & Bell, 2014). Especially since the answers conducted from these studies are of non-numerical nature (Silverman, 2016), it requires the results to be interpreted, making it important to carefully consider the study set-up and how it should be performed (Easterby-Smith, Thorpe, & R Jackson, 2015). For example, Silverman (2016) mentions consent, confidentiality and trust to be aspects that should be concerned in the gathering and assessment of the data in a qualitative study.

In order to ensure the projects validity and quality, these two ways of conducting research was combined, i.e. gathering both quantitative and qualitative data. In literature, this is by Brannen (2017) referred to as ”between-methods”, indicating the use of multiple research methods to be applied on a single object to triangulate the results. For the study performed, this is presumed to create a correct and realistic picture of the situation, having complementary methods to strengthen the validity of findings. This is also similar to the framework presented in the article by Dubois and Gadde (2002), commonly used to perform case research. This research framework aims to create a connection between reality and a theoretical explanation formed by literature. Additionally, this method is used to form a direction for the case study, referred to by the authors as ”systematic combining”, which can be seen in figure 2.1 (Dubois & Gadde, 2002). The reasoning was based on the observations made on the processes studied, which was complemented with interviews and secondary data. The data was analyzed and evaluated based on the selected analysis method, and was compared with empirical data gathered from literature, to create a likely conclusion to base future improvements on.

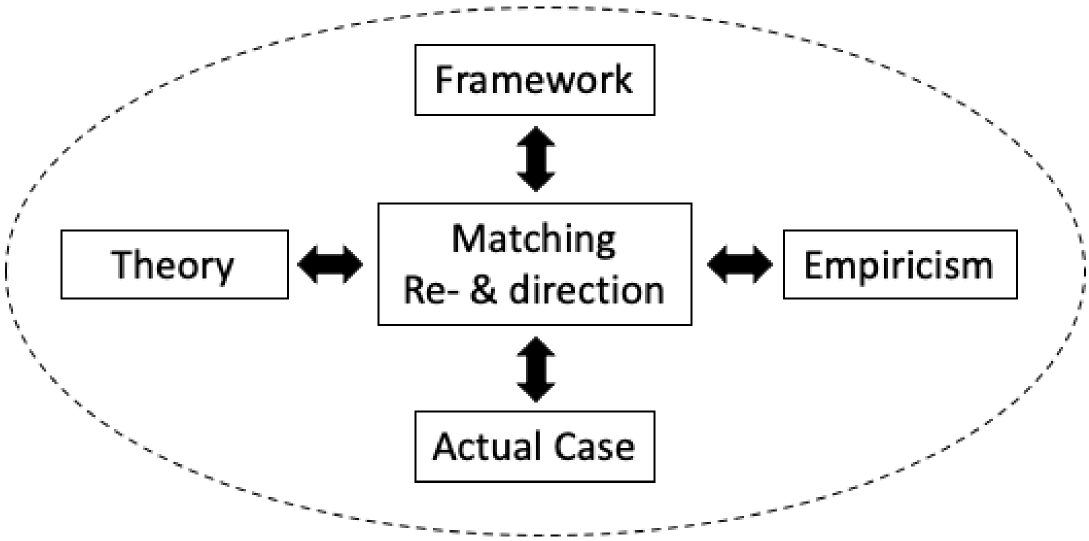

Figure 2.1: Framework: Systematic combining (Dubois & Gadde, 2002)

2.2 Research Methods

This part involves the research methods and techniques used to gather scientific data to be used when evaluating the current situation, and further in the process to base findings and conclusions on. For this project, the techniques presented in the following sections are intended to be used to gather data. These are selected to complement each other, and to give a picture of the operations corresponding to reality. Additionally, a framework for data analysis will be presented. This will be used as a basis for how to handle and analyze data, consequently leading to a consistent and effective process to extract valuable information.

2.2.1 Interviews

When conducting interviews, the structure may vary from being more or less structured (Bryman & Bell, 2014). In the book by DiCicco-Bloom and Crabtree (2006), three different structures are presented; unstructured, semi-structured and structured. Unstructured interviews are based on continuous processing of information gained from the interviewee during the progress. With the help of some guidance in form of topics or selected questions, the interview is similar to a conversation, giving the interviewee freedom to reason around subjects. These interviews are often conducted in relation to other research methods, e.g. observation studies, and does not give the interview subject time to prepare beforehand (DiCicco-Bloom & Crabtree, 2006).

On the contrary, semi-structured and structured interviews make use of predetermined questions. However, semi-structured interviews have more open-ended questions, that allows the interviewee to answer freely and creates an open dialogue, while still having predetermined questions to control and, to a certain degree, limit the discussion (DiCicco-Bloom & Crabtree, 2006). Structured interviews are often referred to as standardized, as they make use of the same questions for several interview subjects. This provides a basis to compare answers from several interviewees in a simple way (Williamson, 2018).

Interviews was used during the project to gain information and to build a greater understanding for activities performed, and related problems in the packing processes. The interviews was conducted mostly in an unstructured manner, while observing the activities performed in the different flows. Additionally, some semi-structured interviews was also conducted, as a complementary to the data gathered through own measurements, to get a deeper and more thorough reflection upon how the processes are to work with, and possibly, by the workers, identified problems.

2.2.2 Observational studies and Measurements

Observational studies are used to get an understanding of how an activity appears when observed in reality, often studying social interactions involved in the activity (Bryman & Bell, 2014). This is often done in combination with interviews, as the observational studies can be performed in order to identify behavior or problems not detected during interviews or other techniques used beforehand. Additionally, Bryman and Bell (2014) says that the results from an observation study can be skewed due to the subject studied being impacted by the presence of a spectator. However, there are techniques to handle this, but the reliability of the studies have to be considered and taken into consideration when evaluating the results (Bryman & Bell, 2014). Apart from only observing the processes, additional measurements was performed.

This kind of study was used to create a better understanding about the activities involved in the packing process, and those activities performed at the packing stations. Additionally, this helped to identify problems and areas for improvements not mentioned during the interviews, and vice versa. Furthermore, this helped to collect complementary numerical data, to be used in combination with the secondary data found in the company database, both to calculate fill rate and time efficiency. Foremost, the measurements will consist of time studies for the activities performed in the processes, but will also contain the authors own estimations of the fill rates observed in the packages. If possible, probably mostly based on secondary data, calculations for fill rates will be done, based on the volumes for all products in a package in relation to the volume for its load carrier. This structure will hopefully make it possible to compare the fill rate achieved in packages in relation to efficiency in the processes.

2.2.3 Secondary data

Secondary data can be used to gain additional information in related topics, e.g. through bench marking or case studies performed in different markets. However, some secondary data might not be suitable for the current study, since the primary purpose of studies often is formed to a specific context, involving other variables, thus affecting its applicability to the project (Hox & Boeije, 2004). This demands the secondary information to be carefully interpreted and implemented to the current case, to ensure the validity of the data, i.e. that the information gathered is applicable to the project (Bryman & Bell, 2014).

In the report, secondary data was used to complement the data gathered through interviews and observations. Foremost, this involved master data from Schenkers own data base, but was also data found in related industries in literature. In this study, secondary data from Schenker's own database containing fill rates for the different customers, load carrier usage, and load carrier content was used. Additionally, secondary data was gathered through literature to provide a theoretical background to the topic.

2.2.4 Data analysis

To make best use of the data gathered during the project, a suitable method to evaluate and analyze data has to be conducted. In this case, a method that can be directly applied to with the case company, being Schenker, was specifically applicable to the project. However, this is mostly connected to the collection of numerical data, whereas information produced through interviews will have to be evaluated in regards to context and subjective interference.

The process of evaluating quantitative data will at first hand be done through univariate analysis, presented by Bryman and Bell (2014) to be the comparison of single variables. This aims to find simple relations to the packing process and the fill rate, not demanding any complex algorithms to discover hidden correlations (Bryman & Bell, 2014).

When it comes to evaluating qualitative data, Bryman and Bell (2014) suggests a thematic analysis to be used. This way of interpreting data is based on identifying and describing patterns found in the collected data from techniques such as interviews and observations. This will involve an evaluation of significance of the data gathered, i.e. considering aspects influencing the results in different way (Bryman & Bell, 2014).

2.3 Research Quality

This section provides a reflection of factors that affect the quality of the data gathered through the project, in regards to the different methods used in the progress. Bryman and Bell (2014) focuses on two concepts connected to research data quality; reliability and validity.

To begin with, reliability in this context is explained by Bryman and Bell (2014) as the consistency of the measurements made. This is separated into three factors being *Stability*, *Internal reliability* and *Inter-observer consistency*. Stability explains how a measurements is affected over time, thus giving a hint on how the accuracy of the study will change if the structure is not changed. Internal reliability comes in hand when evaluating the coherence of measurements, i.e. to what degree different measures are linked and if the result can be evaluated based on some form of relatedness. Inter-observer consistency refer to the consistency of measurement when performed by several actors (Bryman & Bell, 2014).

Secondly, validity is related to how well a measurement actually measures what is intended to be studied (Muijs, 2010). This can be explained by a tool showing precise results, however if the results are not correctly associated with the concept being studied, the validity of the measurement is low (Bryman & Bell, 2014). This explains why validity is of great importance, since the research and results would become neglectable if not being applicable to the case (Muijs, 2010). To cope with this, techniques used should be carefully considered before use. Consequently, the purpose of a specific measurement must be specific and clear to why it should be performed and how it provides information to the study.

These concept will be carefully considered when evaluating the data gathered with different tools and methods. According to Golafshani (2003), these concepts are foremost connected to qualitative research, as studies performed in this manner are more prone to involve different kinds of bias. Especially when it comes to reliability, the consistency of these measures might be hard to accomplish (Golafshani, 2003). Interpretation of these results might also be hard to connect to the case, that is to identify and extract relatable information from, for example, interviews.

When it comes to quantitative research, similar problems occur, but rather surrounds the identification of patterns in data, and to be aware of fluctuations and bias (Bryman & Bell, 2014). The abductive approach in combination with different techniques, and knowledge of factors impacting the quality of the data, should help to counteract these factors impacting the overall quality of the research.

2.4 Research process

This study focused on two omnichannel customers to Schenker and one customer that was focused on single flow delivery to stores. As the study focused on Schenker as a 3PL, the companies studied was compared to identify issues that could arise with omnichannels, but foremost focusing on how to improve efficiency and achieve higher fill rates in the packages sent, regardless of the destination. Additionally, the packing processes have an effect on the consolidation of goods sent to either stores or end-customers. However, as the study is focused on the fill rate in the packages, achieved benefits in related areas was considered as secondary. Based on this, a process to study the subject is formulated below, describing the processes and methods used to collect information during the progress of the project.

2.4.1 Step 1 - Observations

The first step was to grow a perception of how the processes are performed for the different customers, both to map out activities performed and to identify differences in the various flows. This was done with the help of observations at the packing stations, to give a view of how the steps are performed. Conversations and unstructured interviews with the workers during the observations gave additional input about the tasks. This allowed the employees to put forth thoughts and opinions about their tasks, and what problems they themselves have encountered. These interviews were based on the questions presented in appendix A.1, however asked more freely in relation to what was performed during work tasks, letting the interviewees reason more freely and come with own input apart from the questions.

2.4.2 Step 2 - Data gathering and measurements

As a second step, data from the different customers and flows was collected and analyzed. The data gathered was focused on information that could be used to calculate fill rates and to find various correlations between fill rate and time efficiency, or other issues. To begin with, measurements where formulated and completed to give a numerical basis for identifying problem areas, in this case being unnecessary man-hours and low fill rate. As the study was performed with three different customers, all with different layouts at the Schenker facility, the measurements used had to be standardized to achieve high reliability and validity. Hence, the metrics focused at was the fill rate and time to perform the activity of packing one unit, i.e. time efficiency. For the study, this was done to give a measurement of how time efficient the packing was in relation to fill rate in the packages.

Most of the numerical data was gathered through Schenker's own database with secondary data for every individual customer. This information contained foremost data on fill rates and load carrier characteristics, being able to be sorted for the different customers and flows. Additionally, video recordings and time studies was performed to gather time efficiency data, i.e. times to perform certain activities and how the time between these are distributed. This also helped discover unnecessary tasks and inefficient work being performed. The observations and measurements also gave a hint on how many boxes needed repacking or cutting down.

Apart from the numerical fill rate, calculated based on the added volumes for all products in an order to be compared with the volume of the load unit they were packed in, a perceived degree of how full packages was also introduced, giving a general idea of how full a box appeared to be regardless of the numerical number. The observed carriers was described in terms of empty, overfull or moderate. To explain this more in depth, the empty boxes was identified as boxes that could be cut down to decrease the box volume, thus increasing the fill rate of the package, however adding an activity and increasing the time to perform the packing. Similarly, overfull boxes either needed repacking, a lid or demanded additional effort to close the box, also increasing time and resources demanded. Moderate was defined as boxes not needing additional work except for the standard routines.

2.4.3 Step 3 - Interviews

Furthermore, additional interviews was performed as a third step to collect complementary information from persons involved in the processes. Most interviews were conducted in an unstructured manner, foremost with employees working in the packing. In addition to these, two semi-structured interviews was performed with the group leader and the team leader for Company C, to collect complementary data for the flow lacking numerical data.

Questions used as a basis for these interviews can be found in appendix A.1. These were based on a number of subcategories, beginning with a number of general questions, with follow ups on more specific areas in the packing process, regarding improvements and quality, and at last fill rate. The information was used in the analysis as a complementary source.

2.4.4 Step 4 - Compilation and analysis of data

The last step was to compile the collected data and information. Data was collected with the support of video recordings, to simplify the process and enabling more information to be caught. This was especially helpful to map processes and involved activities in more detail and to collect times for the activities performed at the packing stations. For the interviews, audio recordings were used. The data was used to find correlations between fill rate and efficiency, whereas the information from workers and observations gave a basis for discussion on how different aspects and activities affects the factors measured, and how these can be impacted to possibly improve fill rates without decreasing efficiency. Based on the findings, the most crucial correlations was pointed out, and critical problem areas was identified. These worked as a basis for the proposed strategies to improve the current flows in regards to fill rates and efficiency.

After all data was compiled, an analysis was made on the result to identify issues and connections between the factors that influence fill rate and efficiency. This was done with the help of an cross-case analysis, to compare results and find similarities and differences.

3 Theoretical Framework

The following chapter gives an introduction to theory used in the project, where the literature studied supported the research done during the project. The chapter will provide information in the areas of third party warehousing and omnichannels to provide an understanding on how these are related and the challenges omnichannels entails to the warehouse operations. The packing process will also be explained to give a context to the operations treated in the thesis. Continuously, advantages and disadvantages of packaging materials will be explained and how it affect the packing process. Supply chain performance is then discussed to explain how these affect the different decisions made in the warehouse operations. Fill rate will be discussed to provide a definition of fill rate, explain fill rate in different contexts, and how it can be measured. Efficiency is explained to give the reader this project's definition of efficiency and what operations that affect the efficiency. Lastly the area of green logistics are presented to explain how the above topics can be related to sustainability.

3.1 Third Party Warehousing

As part of the 3PL growth, more companies make use of outsourcing their warehouse activities (Chen, Hum, & Sun, 2001). This kind of outsourcing is by Chen et al. (2001) referred to as third party warehousing (3PW). The increased outsourcing can be explained by the fact that the rising competitiveness in many sectors has led to an increased specialization in activities performed, which compel companies to focus on their core competency (Malak, Hafeez, & Zhang, 2002; Maltz, 1994). It is also a reaction from the increased demands set by customers that forces companies to be reactive and flexible, while keeping quality at a high level (Chen et al., 2001). For 3PW's, the main services provided is the storing of raw-material, semi-finished goods or finished goods, however, related activities such as receiving, picking and packing, shipping, consolidation and other value added services are often performed (Gudehus & Kotzab, 2012; Hamdan & Rogers, 2008).

Furthermore, Chen et al. (2001) describes 3PW as a long term commitment from both parties involving fixed contracting over several periods. This is due to the characteristics of the service, as it is not performed within a limited time and with one single act, but is rather a continuous service. The contracts are written to ensure both enough capacity for the company buying the service, and to ensure profits for the 3PW provider. However, this does also create problems, for example when deciding capacity needed during the contracting length, due to the fixed space at the warehouse and the often fluctuating demand for the customers (Chen et al., 2001).

3.1.1 Logistical outsourcing

As mentioned by Chen et al. (2001), some issues arise during the outsourcing of warehouse activities, but not all are related to the contracting. Some trade-offs have to be made in the operations performed by the company providing the services. This is due to the fact that more efficient processes creates financial benefits for all parties, however, there are aspects related to customer satisfaction that has to be considered as well (Waters & Rinsler, 2014). In many cases, there are performance indicators that are more or less important for the 3PL and customer respectively. Whereas the 3PL has to develop performance excellence to create profits and stay competitive by decreasing expenses, firms hiring 3PL's has their own customers to satisfy, increasing the demands to be fulfilled by the 3PL (Hamdan & Rogers, 2008).

3.1.2 Single- and multichannel flows

In distribution systems, single- and multichannel flows are the most common. Singlechannel flows does only have one flow of goods, between two nodes in a transport network. This means that the customers are only reached through one distribution option, i.e. either through stores or through e-commerce channels. On the contrary, multichannel flows consist of several flows, e.g. a company selling products through both stores and e-commerce, opening up several ways to distribute products to customers. These flows are handled and coordinated separately, not having any of the channels overlapping. The goal with this is to make it available for customers to buy or order products in a, for them, preferred way (Verhoef, Kannan, & Inman, 2015).

3.1.3 Growth of omnichannel flows

Recent years rapid growth in the e-commerce sales has changed the way logistics has to be handled. The large number of different flows of goods from several channels has increased the complexity in the supply chains. These types of flows are called omnichannel flows, which is a term describing a flow of goods to both stores and end customers. This is similar to a multichannel flow, however in an omnichannel flow, the store and end-customer channels are fully integrated. To the end customer there should not be any difference between the two flows e.g. they should be able to order online and pick up the order in a store, or return an order they received at home to a store (Hübner, Wollenburg, & Holzapfel, 2016).

Omnichannels have emerged from companies trying to increase their competitiveness by giving customers greater freedom of choice, leading to the logistics part of the company having to consider several possibilities for delivery and making it harder to forecast from a supply chain perspective. At the same time, customers demand higher and higher service levels and perfect order fulfillment, which makes the logistics even more complicated to design (Hübner, Holzapfel, & Kuhn, 2016). According to Kembro et al. (2018), this has led to a greater customer focus, putting more emphasis on value adding services. In relation to this, the use of 3PL has shown great results to increase competitive advantage, mainly because of these companies ability to help manage their customers supply chains by integrating necessary logistic services (Ren, Choi, Lee, & Lin, 2020). As Waters and Rinsler (2014) mentions, this might be one of the reasons explaining the increased use of 3PL, as the increased complexity following the growth in online sales impacts the decision of outsourcing instead of handling logistic activities in-house.

The use of external logistics specialists are more commonly used to develop new solutions for omnichannels and create capabilities to differentiate themselves from competitors, aiming to increase customer value (Bernon, Cullen, & Gorst, 2016). Furthermore, additional services are likely to emerge to keep customer satisfaction at a high level. One of these are new and more developed packing processes, but could also involve related activities (Wallace, Johnson, & Umesh, 2009). Specifically for the packing process, the omnichannel flows have forced companies to develop new models how to handle both store and customer delivery (Kembro et al., 2018). In many cases, this inflict expenditures that makes outsourcing options more profitable. Additionally, the integration of multiple channels and online sales forces 3PL's to handle mixed picking, i.e. both picking single products and batches. In combination, requirements are often different depending on the customer, adding other types of unique services to be integrated to the packing process for specific customers (Kembro et al., 2018).

Coordinating practices are also of importance to ensure fast and accurate deliveries, especially when the complexity increases with omnichannels (Larke, Kilgour, & O'Connor, 2018). This in combination with the increased amount of services provided, and customers expecting short lead times, require well developed information systems (Kembro et al., 2018), and can in specific cases be enough to create a need for a higher degree of automation (de Koster, Le-Duc, & Roodbergen, 2007).

3.1.4 Omnichannel and e-commerce effect on logistic services

The online trend and increased sales through e-commerce has come to involve logistic services more and more (Langley Jr & Holcomb, 1992). This demands companies to be more flexible when it comes to volumes, as the characteristics of parcels vary with a greater amount of customers, each having different requirements (Adivar, Hüseyinoğlu, & Christopher, 2019).

With the changing characteristics of the market and the growing use of online sales, the customer experience has become increasingly important, and is experienced through several points in the supply chain (Adivar et al., 2019). This is connected to the aspect of differentiation, mentioned by Fugate, Mentzer, and Stank (2010), but have to be related to the aspects of efficiency and effectiveness to be able to simultaneously have a high performing chain to stay operationally competitive. Furthermore does the increasing environmental awareness not only affect brand image at the point of purchase, but is currently a result from the whole product chain. Consequently, 3PL's has to consider not only their own productivity goals, but also the ones from end-customers, to satisfy their customers (Adivar et al., 2019).

3.1.5 Increased complexity and sustainability impact

Even though there is scientific research in the subject of achieving sustainability through the packing process (García-Arca, González-Portela Garrido, & Prado-Prado, 2017), the introduction of omnichannel flows complicates the transition (Hübner, Holzapfel, & Kuhn, 2016). Not only do e-commerce make the flow complex, but according to Mangiaracina, Marchet, Perotti, and Tumino (2015) it also has a negative effect on the environment, increasing the amount of green house gases (GHG) released. This origins from the increased amount of small orders being shipped from warehouses and the increasing amount of cross-continental orders (Romm, 2002), often leading to low fill rates in parcels, thus increasing waste and package material needed (Mangiaracina et al., 2015). Additionally, García-Arca et al. (2017) states that actors along the supply chain has different requirements on packages, setting their own demands, forcing the design to coordinate these demands. This in combination with the increased number of actors being involved in many chains, often specializing in their own area of excellence, makes the coordination of demands and the packing design even more complex (García-Arca et al., 2017).

3.2 The packing process

The growth of e-commerce has made the packing process for 3PL companies more complex, as many customers in different markets with a mixed type of product characteristics have to be taken into consideration when designing the packing processes. Additionally, the different flows require the goods to be handled in separate ways (Napolitano, 2013). Often, goods to be shipped to stores are carried out in larger volumes, consolidating as many packages as possible to utilize available volume and minimize the number of transports needed (Alexander, 2014). Online sales going directly to private customers are often carried out in smaller volumes being transported to the same location, still demanding fast response rates while having greater problems consolidating orders since the customers are outspread (Kembro et al., 2018).

3.2.1 Packing while picking

In packing while picking, secondary packing is involved in the picking of orders, as the orders are picked and placed directly in parcels. This method for packing decreases the amount of nodes in the warehouse, however adding time to each picking round, decreasing picking rates and puts attention away from the prime activity (Richards, 2014). Hence, according to Richards (2014), this means that not only does the picker have to perform extra activities, it also decreases the utilization of forklifts, which in many cases are considered to be a scarce resource.

3.2.2 Packing as a separate process

In some cases, a separated process is created to deal with packing (Richards, 2014). This is most often suitable when dealing with large amounts of packages, where a separate process can be economically beneficial and provide a more efficient solution. The separated station also facilitates additional activities to be performed, as for example quality control (QC), adding protective material, weighing, or labeling (Richards, 2014).

3.3 Packaging material

Packaging material are of great importance in logistics, as they serve several functions, for example containing, protecting, communicating and preserving its content (Chan, Chan, & Choy, 2006; Hellström & Saghir, 2007). Additionally, packages increase the stackability of products, thus also improving the transport efficiency. However, packages add both weight and volume to goods being shipped, inflicting costs and creating waste (Pålsson & Molina-Besch, 2014). According to Piecyk and McKinnon (2010), fill rate, which is closely connected to the packing process, is one of the key indicators for environmental performance. Additionally, the development of a system with high fill rate performance, has shown to reduce both environmental impact and transportation costs (Kohn & Brodin, 2008).

The packing process is often separated into different levels, depending on which level is to be investigated in a specific context. Hellström and Saghir (2007) presents these as tertiary, secondary and primary packaging. The packaging material that encloses the product is the primary packaging. When one or several primary packages are packed together in a load carrier they are packed in the secondary packaging material. Tertiary in this case is on a consolidated level, focusing on the stacking of several secondary parcels or packages (Hellström & Saghir, 2007), which to a greater extent impact the transportation, thus the optimization of vehicles (Wong, Tai, & Zhou, 2018). In this project, the secondary packaging level and related fill rate is of greatest relevance since the main process studied is the packing of primary packages to a load carrier on the secondary level.

The main purpose of the secondary packaging level is to group products together and protect them during transportation. One of the most common materials used for this type of packaging is the corrugated board box which has several characteristics that is wanted in secondary packing, as for example stackability and durability (Coffin et al., 2011). Furthermore and as mentioned in the section above, there are different ways to combine the picking of orders and the process of packing. In the actual case of a 3PL company, there are two relevant packing setups, the packing is either done through the packing being integrated with the picking, or separated into its own process, thus being carried out by another worker at a packing station.

3.4 Logistic performance targets

The increased competition on the market in combination with higher customer demands has led to companies having to put more focus towards creating customer value. In the article by Fugate et al. (2010), this is referred to as differentiation, i.e. the creation of additional value for the customers to distinguish themselves from competitors, which often appears as requirements set by customers or end-customers.

In logistic systems, there is a lot of focus on monetary targets, i.e. creating profits through the practices performed at the company, which is necessary for the company to stay profitable and competitive. However, there are non-monetary measures that will affect these targets, such as quality and other performance requirements set by customers (Gudehus & Kotzab, 2012). Additionally, in the context of warehousing, Gudehus and Kotzab (2012) mentions personnel costs and total transportation distance to be targets to minimize, whereas the fill rate of parcels and vehicles should be maximized. Furthermore, customer requirements can sometimes limit to which extent these targets can be pursued. Most often, these requirements are concerning quality aspects such as reliability, shipment quality, and order fill rate (Gudehus & Kotzab, 2012).

For the project, the above mentioned targets of fill rate and costs related to performing the packing are of greatest importance. As the project is focused on the packing process, these targets gives a holistic view of achieved performance for the processes studied. Furthermore, as mentioned by Gudehus and Kotzab (2012), the different requirements set by customers will affect these measurements in different ways, depending on the specific company and which processes that are outsourced to Schenker.

3.5 Fill rate

Fill rate is often used in several different contexts, such as efficiency, environmental, and/or cost, when measuring the performance of a logistic system (Santén, 2017). Hence, the fill rate can be measured in different ways depending on the situation and what goal it should correspond to, providing information about e.g. the performance of the transport operations, or the overall efficiency of the distribution system. Thus, it is important to specify how fill rate should be measured, and the purpose of the measurement (Santén, 2017).

According to theory, fill rate is easily calculated, as the required capacity is divided with the available capacity in the load carrier (Santén & Rogerson, 2018). In practice, however, it is a rather difficult metric to calculate (Santén & Rogerson, 2018), where in many cases the data provided by companies to calculate the fill rate is either incorrect or non-existing (Pahlén & Börjesson, 2012). Cause to further complexity, the term is used similarly for different levels in the shipment process, in which fill rate can be calculated in several different ways (Santén & Rogerson, 2018).

For example, fill rate can be used for the different levels in the packaging, i.e. primary, secondary and tertiary, as well as looking at to which extent a vehicle is utilized in terms of weight and volume (McKinnon, Browne, Piecyk, & Whiteing, 2015). Additionally, Ljungberg and Gebresenbet (2004) mentions deck area, and Santén and Rogerson (2018) mentions height and empty running as other aspects that can be considered when measuring the fill rate, however, foremost being applicable when looking at vehicle level, and not directly in the packing process. Furthermore, the article by Santén and Rogerson (2018) argues that considering weight and volume combined provides a more comprehensive view on the fill rate achieved in shipments, since these are both dimensions that affect how well a vehicle can be utilized.

3.5.1 Ways to evaluate fill rate

Weight is the most commonly used factor when measuring fill rate and measures the utilized weight on a transport (Santén & Rogerson, 2018). According to Mckinnon (2010) weight has historically been used as the measurement for fill rate since it is easier to calculate than other metrics, such as volume. Ülkü (2012) define fill rate based on weight as *”the ratio of the actual weight of goods carried to the maximum weight that could have been carried on a laden trip”*.

Volume based fill rate measures the total amount of utilized volume in the packages or trucks. Accordingly, it is the primary, secondary and tertiary levels that are measured.

The primary level is often used when referring to the level in which a product is placed in a package, the secondary when several primary packages are consolidated into one single package, and tertiary is the last level where several a number of secondary packages are stacked on, for example, a pallet (Hellström & Saghir, 2007).

When looking at vehicle fill, Potter and Lalwani (2008) defines it as *"the volume of products actually despatched against the transport capacity deployed for the movement"*. However, in packing, this would have to be changed to look at a more detailed level of the transportation, namely the load carrier capacity compared to the volume of the product or products it carries. To give a more comprehensive measurement of fill rate both weight and volume is considered and a more adapted definition has been formulated by McKinnon and Ge (2004) as *the ratio of the load carried (required capacity) to the maximum load that could have been carried (available capacity)*, which better describes the relation between used and available weight and volume.

3.5.2 Fill rate in packages

To ensure a high fill rate in trailers or containers, packaging on all three levels (primary, secondary and tertiary) need to be considered. In the optimal state, primary packages should be designed to fit the load carrier used for despatch and storage, or vise versa so that load carriers are designed to fit the products to be contained as well as possible, to fully utilize available space (Richards, 2014). This is especially important in omnichannels, since in many cases, the use of traditional package material for e-commerce flows lead to low fill rates and added waste. Additionally, the long distance shipments increase the importance of achieving high fill rates in packages, to utilize the available volume and weight as much as possible (Pålsson, 2018). If the available space in packages could be fully utilized, while keeping the use of packaging material to a minimum, fill rates would be increased, thus decreasing the transportation need. As a result, this would positively impact the environment and decrease transportation costs (Adivar et al., 2019; Kotzab, Munch, de Faultrier, & Teller, 2011).

To create an efficient supply chain, the design of packages plays an important role. A good packaging design enable packages from the different levels to be combined into a unit load, affecting the fill rate and reducing the need for transportation (Zijm, Klumpp, Regattieri, & Heragu, 2019). In recent years, logistic considerations have received more attention in the design process, in order to improve the supply chain efficiency. However, this is still a problem in many material flows where there is a lack of conformity of the packaging design between different parties in the supply chain (Chan et al., 2006).

3.5.3 Measuring fill rate

When measuring fill rate, the dimensions in which it should be measured must be determined e.g. weight and/or volume. When the dimensions are determined, available and required capacity in each dimensions have to be calculated for the different levels examined in the study (Santén & Rogerson, 2018).

The required capacity will depend on the characteristics of the products being shipped, i.e. its dimension, shape, sensitivity, etc, and its availability to be combined with other products into a combined package (Gudehus & Kotzab, 2012). This will affect how well volume can be utilized as some products might be shaped in a way that make it difficult to combine with other products, leaving lots of air in the package (Chan et al., 2006). Volume vise, this makes it important to decide whether the required volume should be calculated by adding the volume of all products in a package, or by estimate the volume of the combined items (Gudehus & Kotzab, 2012). Looking at the weight aspect, everything within a level must be measured and added to the the calculation, i.e. everything within a package has to be added to required weight when looking at package level, and in some cases also the load carrier itself (Santén & Rogerson, 2018).

Furthermore, available volume and/or weight capacity in the load unit has to be calculated. For the packaging level, this will be determined by the available volume in the load unit, and how much weight the carrier can take (Santén & Rogerson, 2018). The weight can also be restricted by what is ergonomically sustainable for the workers, as heavy packages can lead to injuries and affect overall physical health (Calzavara, Glock, Grosse, Persona, & Sgarbossa, 2017). Available weight and volume might also be influenced by the restrictions on the vehicle itself, i.e. how many tons of goods or how much volume that is allowed to be transported at once. Available volume can also be affected by the need for protective material or other supportive functions, filling out or minimizing available capacity (Santén & Rogerson, 2018).

Measuring fill rate is often hard to do in practice, foremost due to the lack of appropriate tools and standardized measurements, especially when it comes to calculate precise volumes (Santén & Rogerson, 2018). As earlier mentioned, there is also a problem with the lack of correct data when it comes to weight but foremost regarding volume. Weight can be measured with or without including packaging and load carrier weight which create inconsistencies in the data (Mckinnon, 2010). Whereas volumetric data is often lacking and has to be collected either by observations or by estimations (Pahlén & Börjesson, 2012).

Based on the identified problems and considerations that has to be taken when evaluating capacity utilization, for this case study in terms of fill rates and how well space is used in load carriers, Santén and Rogerson (2018) suggest an approach to be followed when evaluating such a process. This approach has been developed to consider not only one loading or packaging level, but measures achieved fill rate at several levels to counteract sub-optimization. Moreover, it is applicable to different systems, being adaptable to the number of shipping levels included (Santén & Rogerson, 2018). When it comes to the method provided by Santén and Rogerson (2018), the first step is to define the context and system boundaries where the fill rate is to be measured, for example weight or volume constraints, time period and fill rate levels. Secondly, each required and available capacity should be calculated for every fill rate level studied. Lastly, each fill rate for the levels studied should be calculated and compared to the overall fill rate (Santén & Rogerson, 2018). This does not only provide a detailed view on each and every packaging level, but also a holistic measurement of the efficiency of the overall packing process.

3.6 Time efficiency

One of the fundamental principles of lean production is to create customer value through eliminating waste in the processes. One measure to eliminate waste in the processes is to create a continuous flow where the product flow through the process from start to finish without interruption. Flow can be defined as the movement of a product in the value stream without waiting or delays (Nicholas, 2010). When focusing on flow efficiency the process is optimized to deliver customer value in the shortest possible time. In this report, instead of flow efficiency, time efficiency will be used, defined as ”time used for value adding activities in relation to the total amount of time spent”, similar to the definition by Nicholas (2010).

If the process is set up in a way so that each activity performed on the product adds value, the process will have a continuous flow and waste in the process will be noticed quickly since the flow will be interrupted when the waste occurs (Liker & Meier, 2006). This is supported by Melton (2005) which mention that constraint in the system will cause a lack of flow in the production. Thus, when measuring the flow efficiency the amount of value adding time in relation to the throughput time is measured (Tay, 2016).

3.6.1 Primary and secondary process thinking

Primary process thinking is described by Funder (1999) to be an intuitive way of reacting and process information. This kind of reaction is immediate and can not be controlled, thus being useful in situations which require a fast response. On the contrary, secondary process thinking is described as a controlled way of processing information, thereby being more rational, however being a slower process and require more effort (Funder, 1999).

In the book by Liker and Convis (2012), these both ways of thinking are applied in a work context. In the process of learning the authors use the term of Shu-Ha-Ri, which is built on the steps of developing an effortless execution of work tasks (primary process thinking). When this has been applied, and tasks are solved intuitively, secondary process thinking is engaged to improve processes and ones own way of working. However, the latter is built on the assumption that the workers can perform activities efficiently without hesitation (Liker & Convis, 2012). If this is not the case, the activities will be far too slow, resulting in a process that is not efficient enough, according to the theory presented by Funder (1999).

3.6.2 Seven wastes in production

The lean production system was developed by Toyota and aims to increase the production efficiency by removing or reducing all wasteful moments in the processes. Taiichi Ohno defined seven wastes within Toyotas production system that Nicholas (2010) describes as universal for every organization.

Defects

A defective product is always a source of waste since it either has to be scrapped or repaired. If the product has to be scrapped all resources that has been used to produce it is considered to be waste and if it has to be repaired the extra resources spent on the product to repair it is waste. If the defect is detected by a customer it has even greater consequences since it can lead to lost sales and bad reputation among potential customers (Nicholas, 2010).

Overproduction

Overproduction is when a company produce more than the demand which is considered a waste. The products has to be put in inventory which in itself is a waste and if the demand won't increase the products eventually have to be scrapped (Nicholas, 2010). Producing products for which there is no demand also mean that production capacity is taken from other products, decreasing the production flexibility (Chiarini, 2013).

Inventory

Inventory is a source for many wastes, such as inventory holding cost, tied up capital, increased lead time, and hiding defects of both products and the production system (Nicholas, 2010). Further there is no value added to the products when they are in storage.

Transportation

The movement of products between stock to a process or between processes are seen as wastes since they do not add value to the product (Chiarini, 2013). Excess transportation are often the result of a poor layout design resulting in long distances between processes or within a process (Slack, Brandon-Jones, & Johnston, 2013).

Motion

All motion that do not add value or are necessary in order to add value are considered to be waste and should be eliminated (Slack et al., 2013). Examples of unnecessary motions are searching for tools, walking, and unloading of goods (Nicholas, 2010).

Waiting

Waiting refer to workers or machines that are waiting to perform the next process step. There are several reasons why waiting might occur e.g. waiting for orders, parts or material, waiting for equipment to be repaired, or when a worker are waiting for a machine to be finished (Nicholas, 2010).

Over processing

Over processing are mostly refereed to as performing unnecessary steps within a process (Nicholas, 2010). These extra steps can be necessary due to e.g. poor process design, insufficient tools or machines, or lack of standardization (Chiarini, 2013; Liker & Meier, 2006).

3.7 Green logistics

Green logistics is, together with e-commerce, an area of rapid growth and increased interest. Adivar et al. (2019) states the most fundamental sustainability issues in regards to omnichannel flows and packing are the volume and fill rate of shipped parcels and goods, recycling, smart consumption, and sourcing of local produce and products.

Even though there is a lot of development going on in regard to sustainability, the lack of means to measure improvements in environmental performance and divide it on responsible actors creates problems when evaluating contribution (Mangiaracina et al., 2015). Another problem in this area is, according to the authors, the lack of relevant literature. However, even though the possible effect from a more efficient logistics system could have great impact, the connection between performed activities and environmental effect is hard to distinguish and evaluate (Mangiaracina et al., 2015).

3.7.1 Sustainable transportation

One of the key areas in sustainable logistics is the transportation, which is responsible for 87% of the total amount of GHG emitted from global supply chains, whereas warehouse buildings stands for the rest (McKinnon et al., 2015). The transportation of goods is therefore greatly affected by shipping companies efforts to improve efficiency. One of the areas of improvement is the fill rate, which has been discussed before. This is closely connected to warehouse activities that can help make the flow more efficient, i.e. the packing of products. As transportation is a large part of the total amount of emissions, minimizing the number of vehicles needed to transport a certain amount of goods could have great impact, both economically and environmentally (McKinnon et al., 2015; Santén, 2017; Wong et al., 2018).

3.7.2 Sustainable packing

To begin with, García-Arca et al. (2017) includes the triple bottom line of economic, environmental and social sustainability when evaluating the sustainable work done in companies, in this case related to the packing process. Economic sustainability is most related to the logistics or flow function, as the goal with packages are to simplify logistics activities and to transport goods in a safe and controlled way, aiming to increase efficiency in goods handling and to shorten lead times (García-Arca et al., 2017). However, this can be enabled through standardized sizes on the packages used and a standardized packing process, though not necessarily minimizing material use and optimizing space utilization. If not considering other sustainability aspects, the economic gain will foremost increase margins (García-Arca et al., 2017). Consequently, some of these gains might suffer when considering other sustainability aspects, especially with the increased customer awareness, forcing companies to make trade-offs not to damage the company brand. As a consequence, environmental sustainability is growing, also in regard to the packing processes. The most crucial aspects in this performance measure is, as previously mentioned, decrease waste and consumption of material used for packaging, connecting environmental sustainability to respective function. This is to some degree solved by trying to increase return flows, consequently reusing a larger part of the packaging material, or to recycle it (García-Arca et al., 2017). At last, social sustainability is mentioned in the context of addressing sustainability efforts to customers through the supply chain, showing transparency, honesty and truthful information towards all actors connected to the product (García-Arca et al., 2017).

4 Case Companies

This chapter will present the three companies which the case study performed at Schenker is based on. To begin with, a general connection between the different actors in the chains are described. After that, the three case companies will be described to provide a more detailed context and pre-conditions to the study, marking out differences in the setups.

4.1 Business context

A general description of the current setup and the connections between Schenker, its customers and end-customers at each end of the different chains, is described in figure 4.1. The figure aims to describe connections that are relevant for the study, thus excluding flows that are not necessary to mention. The figure provides an holistic view of how the actors are connected, and how information and material flows in the chain.

To clarify what is presented in figure 4.1, DB Schenker is the main actor and study object in this project, thereby being the focal company. They receive goods from their customers, in the study they are referred to as Customer A, B, and C, hence resulting in both a material and information flow between the actors in the chain. Received goods are then stored and shipped onwards when ordered, either to stores or directly to end-customers. The flow mentioned in omnichannel contexts, i.e. the flow connected to Customer B, consists of all the flows displayed in figure 4.1. Customer C also have shipments being sent to both stores and directly to end-customers, however, they do not offer pick-ups in stores, thus not involving the connection between the online customer and stores. Finally, when it comes to Customer A, the flow does not involve online customers, as the shipments are limited to stores, thus being restricted to flows to and from the focal company.

To sum up, Customer A only distribute their goods through retailer stores, thus having a single channel distribution system. Customer B sell goods at their own stores and through an integrated e-commerce channel, reaching customers with both direct deliveries and through stores, creating an omnichannel. Customer C sell through both own stores and retailers as well as having an e-commerce channel distributing goods directly to end-customers, however the store and e-commerce channels are not integrated, hence Customer C is classified as a multi channel company.

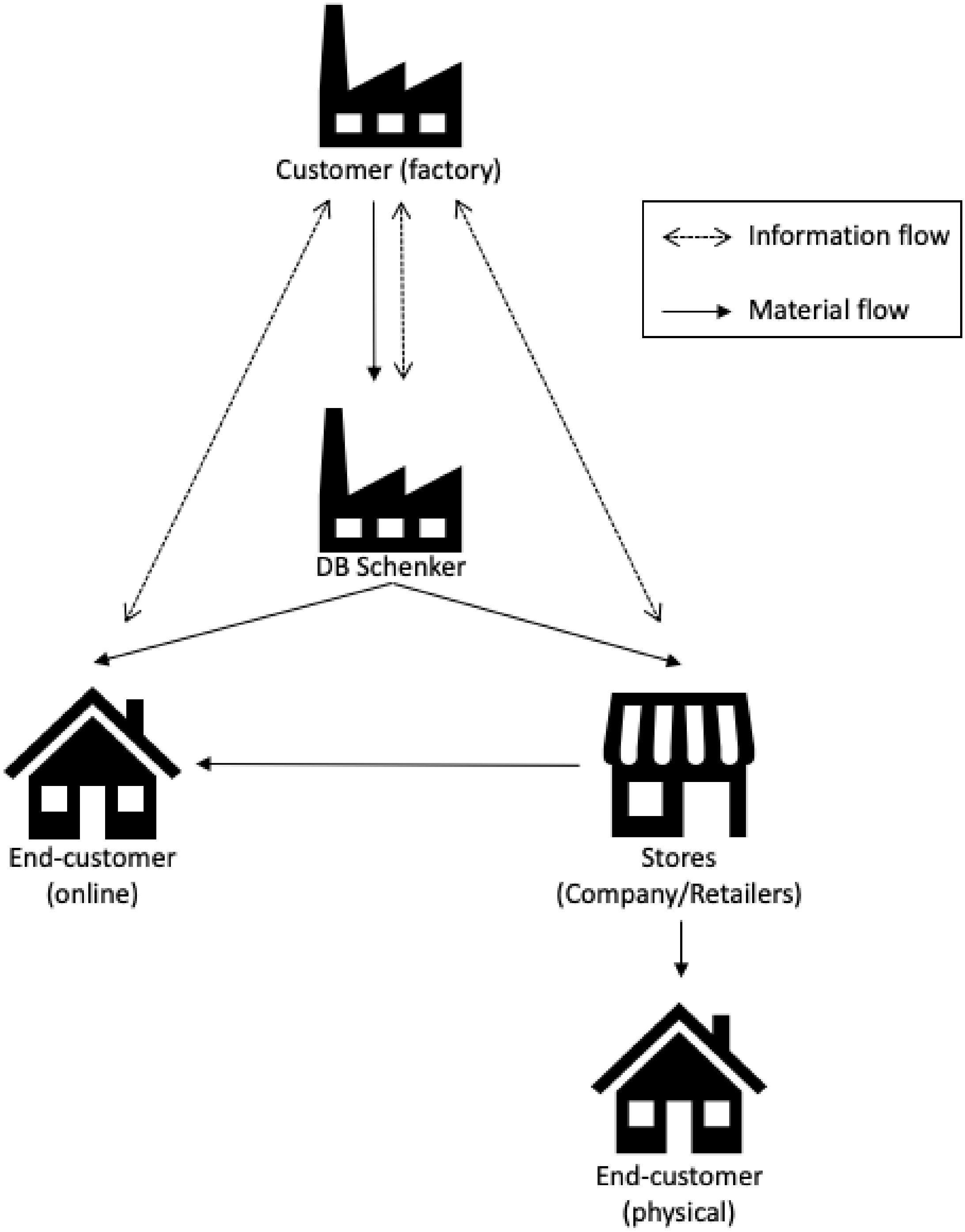

Figure 4.1: Description of material and information flows

4.2 Customer descriptions

In the following section, the companies studied and their differences will be described. This aims to provide a context to each actor, and to distinguish important characteristics of the flows related to the packing process. To compare the case companies and to clarify important differences, the following aspects will be considered, with inspiration from the article by Pålsson and Molina-Besch (2014).

- Logistical conditions
- Product characteristics
- Packing requirements

4.2.1 Customer A

Customer A is a company manufacturing power tools and home improvement products. The products supplied are mainly of physically harder characteristics, in sizes varying from small saw blades to large equipment. The company only handles orders going directly to stores, thus not having any online sales or B2C deliveries. However, as the products are sold to a large number of retailers, the amount of orders are high, with varying product volumes.

4.2.1.1 Logistical conditions

At the Schenker facility, the shipments are separated into six different flows, where two is of relevance to the project since they have a packing station, these flows also have the highest volume of orders, hence they handle the majority of the orders for customer A. One of the flows handles orders with low volume items, henceforth referred to as ”small product pick”, and the second flow of relevance manages larger items, henceforth referred to ”large product pick”, resulting in higher metric volumes.

The small product pick flow use trolleys for the picking, and each picking round contains several orders. For the packing, this means that a number of order arrives to the packing stations simultaneously, stacking up packages in waves. These stations are equipped with roller belts to convey the packages from the drop-off point to the end of the belt, to simplify the process and minimize non-value adding work, also improving the work ergonomics for employees.

The biggest difference in the large product pick flow is the composition of the orders, where there is generally fewer products in each order but the size of the products are significantly larger. The layout of the packing station is slightly different for the two flows due to space limitations where the two different packing stations are located in the warehouse. The difference in layout affect the packing process to some extent where, for example, the walking distances are longer at the packing station handling large volume orders. Additionally, the large order flow has the belts located next to each other, creating a sort of U-cell, whereas the small order flow has separated the belts into several workstations. However, the packing process, which is described below, is designed in the same way and the activities performed are the same for both flows.

When the packages arrive, the orders are scanned and shipping labels and delivery notes are printed, the labels are attached to the load carrier and delivery notes are put in the load carriers. The products are repacked and the boxes are cut down at the edges if possible, when the amount of products do not fill up the box, this is done to decrease the height of the load carrier and thus decrease the total volume, they are packed with protective material if it is needed, and at last packages are taped together and stacked on pallets. The processes are described in figure 4.2.

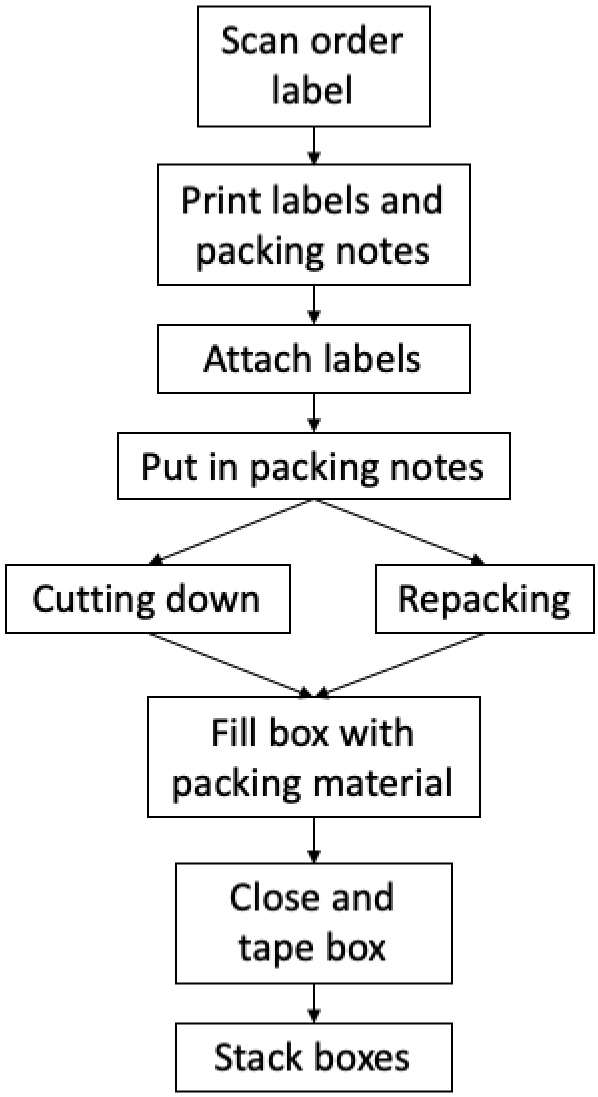

Figure 4.2: Customer A - Process map

Additionally, there is a difference in how the pallets are stacked in the flow. With the large order flow handling a larger variety of different load carriers, including standard boxes and a more frequent use of primary boxes, the stackability is affected. To cope with this, the large order flow has several pallets at the end of the flow to be able to stack different types of boxes more efficiently, whereas the small order flow only has a single pallet.

4.2.1.2 Product characteristics

The products supplied by Customer A are mainly of harder characteristics, thus not being bendable. The products have very different sizes and shapes where there is a mixture between small and big products with different dimensions. This create a problem when products are to be packed together in secondary packages, where an order can consist of, for example, one long product, demanding a big load carrier in one dimension, and several small products, resulting in low volume fill rate and a need for protective packaging material. The products of Customer A can also be heavy which in some cases constraint the packages from being filled in respect to volume, since the maximum weight allowed in a load carrier varies from 10-25kg. Hence, both volume and weight is considered when measuring fill rate for Customer A.

4.2.1.3 Packing requirements

The main requirement by Customer A is to protect the products during transport. As a result of the product characteristics, which create empty space in the packages, there is a great need for protective material in most packages to prevent the products from being damaged during transport. Some stores also require a delivery note to be sent with the package.

Apart from this, goods are shipped with a variety of cardboard boxes, and in some cases with smaller items envelopes are used. At the large product pick some products are shipped in their original package, as they are too large to fit in a load carrier.

4.2.2 Customer B

Customer B is a company in the home textile and furnishing market, both selling their products through stores and e-commerce. The company sells a variety of products, resulting in their flow of goods through Schenker's facilities to have a mix of characteristics.

4.2.2.1 Logistical conditions

The process studied at Customer B is divided into two flows. One flow is coordinated to handle packages that is to be picked and delivered to stores, henceforth called ”store flow”, whereas the other flow is sent directly to customers, henceforth called ”e-commerce flow”. Additionally, some packages are sent to stores to be picked up by customers, thereby being a part of the online sales however shipped with store goods. This creates an omnichannel flow, where several flows has to be integrated to the processes. Currently, the processes are separated at the Schenker facility, meaning that both picking and packing for the different flows are done at different locations. When the e-commerce orders that should be delivered to a store are picked and packed in the e-commerce flow they are integrated into the shipping process for stores. This create an extra step in the packing process for these orders since all the orders being delivered to the same store have to be consolidated into one package.

For the e-commerce flow, the orders are picked with trolleys adapted to the varying characteristics of the products from Customer B, also being able to carry several orders per picking route. When the picking is done, the orders are handed over to the packing station, where they are packed in load carriers. As the company has a lot of non-fragile products being distributed, most orders can be packed in plastic bags. However, when handling orders with larger volumes or fragile products, boxes are necessary to provide enough space and protection. The different load carriers have both advantages and disadvantages, while the plastic bags does not carry much air, thus leading to high fill rate, it does not provide the same protection, and requires caging to be stacked on a tertiary level and are shipped in a post wagon. On the other hand, boxes requires more effort to be put together and often leads to lower fill rates, however being easily stacked on pallets. However, small boxes are also being shipped in the post wagon since they are difficult to stack on a pallet.

Every order can consist of one or several items of varying size, weight and shape. These are combined in a suitable load carrier, i.e. a plastic bag, a box, or a custom made load carrier. The plastic bags are of two different fixed sizes, holding different volumes. The same goes for the boxes, however, to increase the fill rate of these boxes, they are cut down if necessary to take as little space as possible. Some products require a custom made load carrier since the product is to big to fit in any of the standardized load carriers. When the package has been closed and a label attached, the products are placed either on a pallet, a post wagon or put to consolidation. Products packed in boxes that can be stacked are placed on pallets, whereas plastic bags and odd-shaped packages are placed in post wagons. For consolidated goods, the same process occurs in a later stage when consolidated, however not being included in the scope of the report. The process is described in figure 4.3.

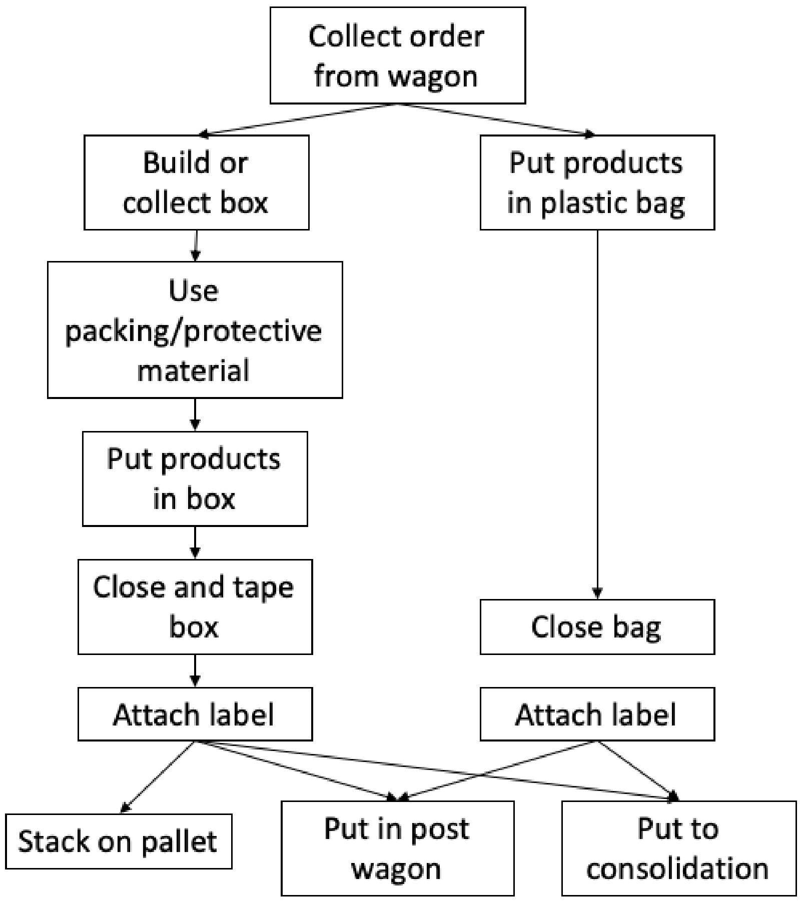

Figure 4.3: Customer B - Process flow for customer shipments

The process connected to the store shipments handles overall larger amount of goods per order than online, often leading to more goods being consolidated. As there is not only full pallet/box orders, but also customized orders with mixed products, there is a need for picking in secondary packages. In the store flow the odd-shaped products are separated into a separate product flow, which allows all orders to be shipped in a standardized load carrier creating a rapid throughput rate. The picking is done in these standardized cardboard boxes, and is handed over to the packing station when ready. As each picking route consists of six packages at a time, the packages arrive in such batches and the picker attaches the label to each package before he drops them of at the packing station. The packing station re-packs the products or cut down the boxes if necessary, explained by the left path in figure 4.4, then close the boxes, and stack the finished boxes on pallets. The right path in figure 4.4 show the process when the boxes arriving at the packing station are picked in a way that the boxes need to be neither cut down or repacked.

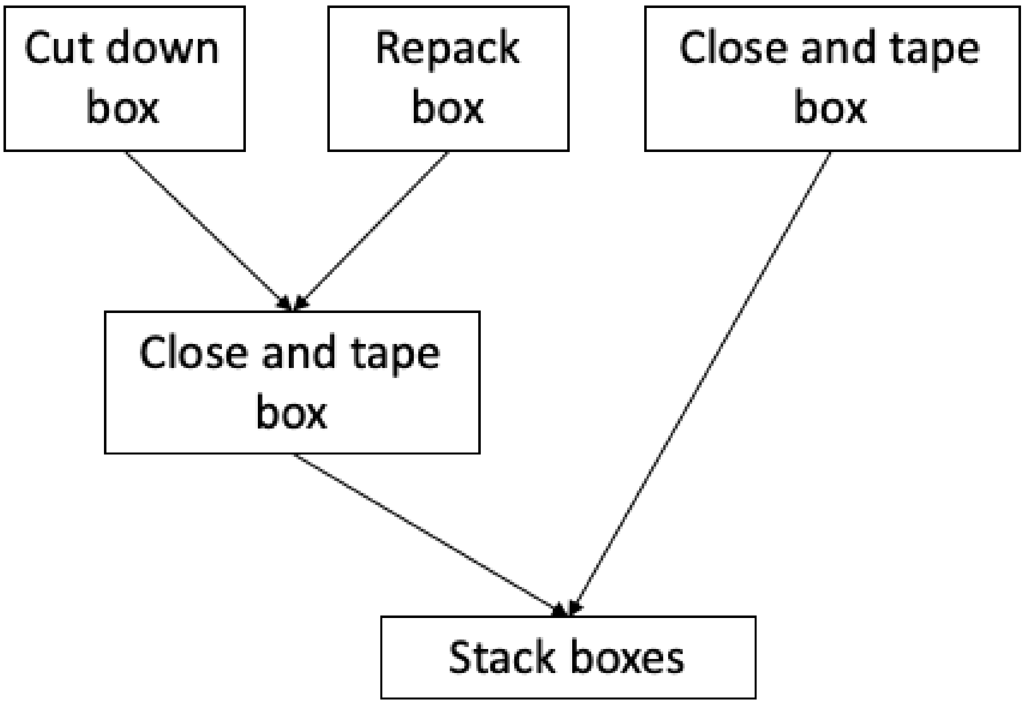

Figure 4.4: Customer B - Process flow for store shipments

4.2.2.2 Product characteristics

The products sold by Customer B is foremost textile products, thus being easily handled since they have a shape that is easy to handle and does not require any extra protection. This makes it possible to package the goods in standardized carriers, more especially in cardboard boxes or plastic bags of various size. Additionally, there a products of harder characteristics, both when it comes to the product itself and some products being contained in primary packages.

There are also some products that are fragile, thereby requiring extra packaging material to protect them from being damaged during transportation, and products with one large dimension making them difficult to handle since they do not fit in standard load carriers.

The products of Customer B are of lighter nature and the weight of the products is not a limiting factor for packages. Thus is the volume in the load carriers the only fill rate factor being measured by Schenker for customer B.

4.2.2.3 Packing requirements

The requirement set by the customer is to ship as few packages as possible and as a result of that Schenker put a high focus on obtaining a high fill rate in the packages. The focus on shipping few packages is clearly displayed in the e-commerce flow, where an extra process step is added to consolidate the orders that should be picked up in a store in order to reduce the amount of packages being shipped.

Most products, e.g. non fragile product delivered to end-customers are shipped in bags, to decrease air shipped and simplify the distribution of the goods. However, orders containing large volumes, fragile products, hard products or products with other characteristics that makes it impossible to use a plastic bag are packed in cardboard boxes. In special cases the product doesn't fit in a plastic bag nor a cardboard box, then the packer has to create a load carrier specifically for that order. The majority of the special cases contain a product with one dimension much larger than the other dimensions.

The fragile products must have extra protection so that they are not destroyed during transport and the products are protected with bubble wrap that the packer enclose the product with before it is put in the load carrier. This must only be done for e-commerce orders where the fragile products are possible to order in other quantities than the amount of a primary package which means that they lose the protective functions of the primary package. Unlike the stores that must order these items in the same quantity as in the primary packages or in multiples of this quantity, thus are the fragile products already protected by the primary package when packed in the secondary package in the store flow. However, the bubble wrap does not only provide protection and thereby having a necessary positive effect, it also fills out the package, limiting the volume available for additional items, and increase the packing time.

4.2.3 Customer C

Customer C is a clothes retailer selling clothes and is labeled as a premium brand. The company has own stores in Sweden and they sell through retailers in the Nordic market, including Sweden, Norway, Finland, and Denmark. They also sell their products through different e-commerce companies as well as their own website.

4.2.3.1 Logistical conditions

The processes for Customer B are divided into several different flows, delivering products to different customer segments. The ones being business to business (B2B) and thereby shipped from Schenkers storage to different stores and re-sellers, are called MZ1, flat packing, and MZ2, hanging goods. Flat packing involves the packing of products that can be laid down and stacked in boxes, whereas hanging are clothing that has to be hung to not get damaged during transportation, such as suits and jackets. Additionally, creating the multi channel flow, is the MZ3 and MZ4 flows, being business to customer (B2C) flows, thus delivering goods according to orders sent from end-customers. MZ4 does only involve packing of single items in small boxes, and does also require each product to be packed in silk paper. The MZ3 is similar to MZ1, however being sent to customers. There are also three different flows for customers with special requirements on how the products should be packed requiring a custom made packing process, these are called MZ5, MZ6, and MZ7. Additionally, the stacking of packages on pallets are separated from the packing process, in contrary to the flows of Customer A and B. Instead, packages are placed on a roller belt that transport them to a separated station. The processes are described in figure 4.5, and is valid for all flows since the same activities are performed, also at the same place.

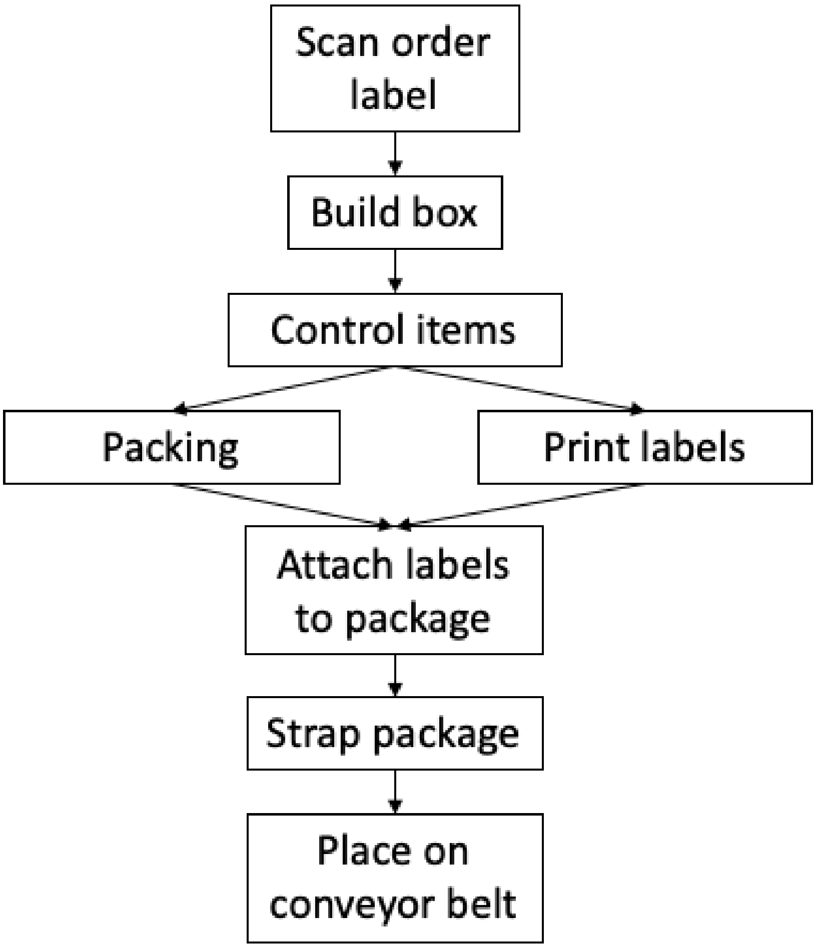

Figure 4.5: Customer C - Process flow

4.2.3.2 Product characteristics

Being a clothes retailer, the items handled are mostly textile products, thus being light and soft in nature. This makes the majority of the products, in theory, easy to handle and pack together to achieve high fill rates. The company also has some products in the categories of shoes, accessories, and watches that have different characteristics, which have to be handled differently since they are hard and are not as compatible to pack together as textile products. Some of the accessories are also very small creating a problem to achieve high fill rate if they are ordered alone, at the same time being easy to pack together with other products. However, since Customer C label themselves as a premium brand, the products have to be handled with care and packed thereafter. Hence, some products has to be hung on hangers instead of being packed in boxes, to ensure that the goods arrive in good shape.

4.2.3.3 Packing requirements

The textile products being handled are mostly non-fragile, thus being easily stacked and combined with other products in packages. However, as the products are considered to be of premium quality, some caution has to be taken. Suits, blazers and jackets are examples of products that are hung on hangers in boxes, to minimize possible damages and wrinkles on the clothing, however only when the order is for more than one item. This requires a special box, having a bar to hang hangers on. Even though this is a good way to protect the products, it is both time consuming, especially when building the box, and difficult to achieve a high fill rate in. On a tertiary level, the dimensions of these boxes only allow four to be stacked on a each pallet, further decreasing the fill rate of the shipment.

The packing is especially important for the goods sent directly to end-customers as they should get a premium feeling when they receive the package to keep the satisfaction at a high level. The end-customers also require a return label to be added to the package. Additionally, Company C have a number of retailers with special requirements, including specific packing order, extra packaging material, or that consolidated items should be sorted by color and/or style.

5 Case study findings

This chapter will present findings made during the different studies performed, i.e. observations, interviews and measurements. The result from the studies will be presented for each customer individually.

5.1 Findings for Customer A

In the following section, findings from the study on Customer A will be presented. On the contrary to the other two case companies, Customer A only has products being sent to stores (B2B). The results for the two flows, small product pick and the large product pick, will be presented in separate sections. The two flows have been described in more detail in section 4.2.1.

5.1.1 Small product pick

The following section will present the findings from observations, measurements and interviews performed at Customer A's small product pick, i.e. the flow handling smaller items.

5.1.1.1 Fill rate

One of the main problems in the small product pick is the fact that the packages have low fill rates. The average fill rate for the small product pick can be seen in table 5.1, where both weight and volume fill rate is presented. The problem with low fill rate appears mainly due to three identified causes and how they interact; product dimensions, order composition, and load carrier dimensions.

Table 5.1: The average fill rate for packages in the small product pick

Fill rate measurement	Fill rate (%)
Volume	49.9
Weight	28.1

The products in this flow are of smaller dimensions, that often are possible to combine and pack together in load carriers to efficiently fill out the bottom area of the load carrier. However in some cases, the area of a product force the load carrier to be have a big area in order for the product to fit. The two most common cases being products with a large square surface and small height, or a product that is long and flat. In rare cases the products in the order then succeeded to fill out the carrier, resulting in an overall low fill rate in these packages. The effect on the fill rate can be seen in figure 5.1, where the box named A2E is mostly used for orders containing the square surfaced type of product and CE6 for products with one long dimension. When A2E and CE6 is used, it can be seen that there are generally fewer products in these orders, this indicate that the squared surfaced products and the long products forces the order to be shipped in a box that is not suitable for orders containing a low amount of products. In table 5.2 the maximum volume and weight for each box is presented and if the box is possible to cut down.

Table 5.2: Volume and weight restrictions for the different boxes used at the small product pick

Box name	Volume (m^3)	Weight (kg)	Possible to cut down
A1E	0.006	10	-
CE1	0.013	20	-
A2E	0.0221	15	-
CE2	0.0242	20	Yes
CE6	0.0244	18	-
CE3	0.074	20	Yes
CE5	0.09	20	Yes

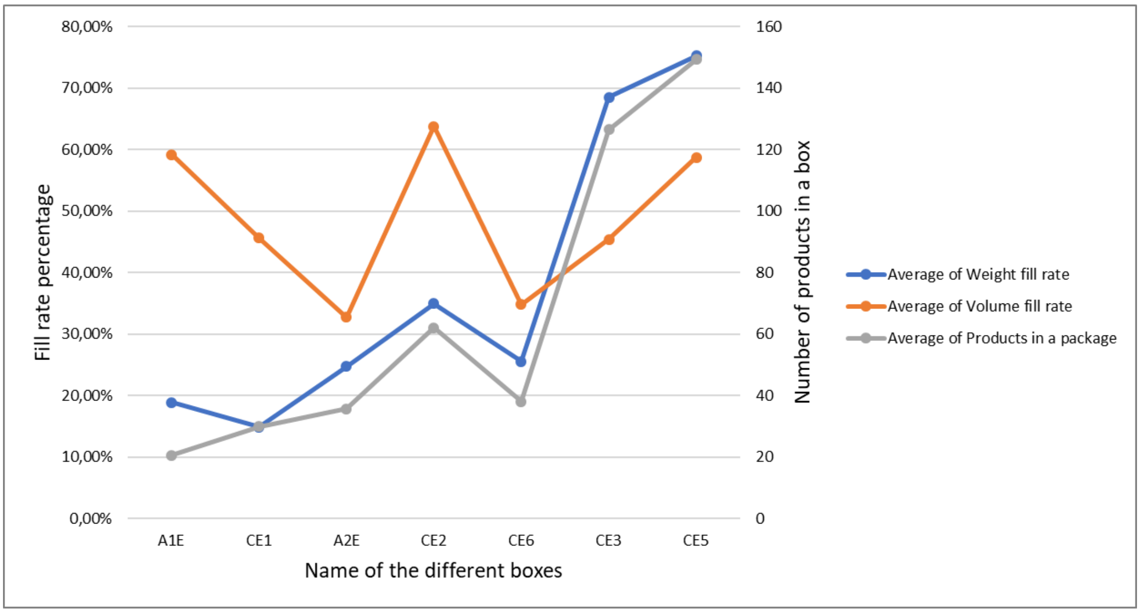

Figure 5.1: The relation between fill rate and number of products for the seven different boxes, smallest volume to the left, used at the small product pick

The order composition is also a factor that has been identified to affect the fill rate and is tightly connected to the odd-shaped products. To achieve a high fill rate with orders containing odd-shaped products the order composition has a big influence. These products either have to be shipped alone so that the load carrier can be custom made, however only happening on rare occasions thus often resulting in a low fill rate, or to be included in bigger orders where there are many other products that can be combined and fill the load carrier. In a small number of cases, these odd shaped items were ordered with enough other items to increase the fill rate to a satisfactory level. Overall it can be concluded that packages with many products have a higher fill rate, which can be seen in figure 5.2.

Where the number of products has a very big positive impact on the weight fill rate and some positive impact on the volume fill rate even though the volume fill rate is flattening around 60 products in a package. One reason for the difference between volume and weight is the fact that when the different load carriers increase in volume the load carriers are bound to almost the same restriction in weight, which can be seen in table 5.2. This is a result of the weight restriction being determined for work environment reasons and is thus not increasing when the volume of the box is increasing.

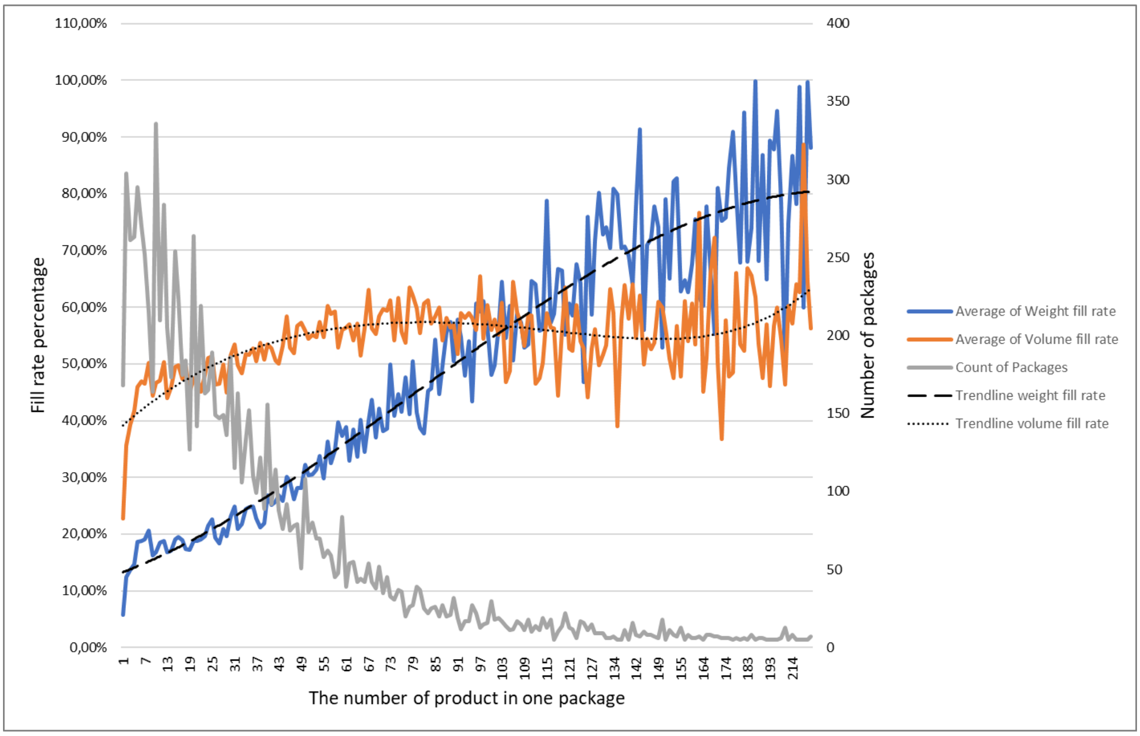

Figure 5.2: Fill rate in relation to number of items in a package

The height of the load carrier is the dimension that has the most negative impact on the fill rate in the small product pick flow. During observations it could be seen that many load carriers were higher than the gods it contained which lead to an unsatisfactory fill rate. This is mitigated by the possibility to cut down the edges of the load carriers to decrease the height and increase the fill rate, however only being possible to do on 3 of 7 of the available boxes. The structure of the boxes, that are possible to cut down, only makes it possible to cut them down a predetermined height, meaning that even if the box is too high, they are not always possible to cut down to the desired height. Consequently, the packages have to be filled with packaging material, thus shipping a lot of air. As a result, the volume shipped is the one represented by the load carrier, varying from the actual volume of the products it contains.

The height problem is confirmed by the gathered data where 75.9% of the load carriers are either cut down, or filled with packaging material, or both to protect the products in load carriers with low fill rate. However, the positive effect of cutting down the load carriers are not fully utilized since the information in not updated in the IT-system nor shared with the forwarding agent. As a results, the system believes that the vehicle is filled to a certain degree, while on the contrary the volume is lower. Consequently, the ordered shipping volume will in many cases be bigger than the actual volume of all the packages that the shipment contains.

A second problem identified is that the different shapes of boxes has an impact on the fill rate and the time spent on achieving a high fill rate on a tertiary level. As a consequence, to fit all the boxes on a pallet in a suitable way, the boxes has to be placed in a specific way, depending on the mix of packages. The robustness and fill rate on the pallet will therefore be dependent on the workers experience. In some cases, boxes are shaped in such a way that they can not be stacked in a good way to fully maximize the capacity of the pallet, regardless of the packers efforts.

5.1.1.2 Efficiency

When studying the efficiency in the flow, the results presented in table 5.3 show that a lot of time in the packing is spent on repacking, cutting down boxes, and filling boxes with fillers, these activities are done to increase the fill rate and to protect the products. In many cases the packer do not cut down the boxes, even when it seems possible. This is mainly due to two reasons, either that the gain to cut down a box is judged by the packer to be too small for the activity to be worth the work, and the box is instead filled with packaging material. Apart from this, the structure of four of the boxes does not allow them to be cut down. The most common of the two reasons is the structure of the box. The

Table 5.3: Average times per package for the packing processes for Customer A's small product pick

	Average (s)	**Share of packs (%)**
Scan	3.6	100
Attach label	5.8	100
Add pack note	7.4	33.3
Attach red label	4.7	33.3
Repack	15.5	17.5
Cut down	14.7	10.5
Packaging material	7.3	75.9
Tape	10.7	100
Stack	6.8	100

During the observations and time studies it was noticed that almost every box that was cut down also had to be filled with packaging material, which means that cutting down the boxes do not remove the extra step of filling the box with packaging material. Even though the boxes that have been cut down do not need as much packaging material the time it takes to fill the box with a little or a lot of packaging material is almost the same. This create a choice between increasing the fill rate in the package, by cutting down the box, or increasing the efficiency at the packing station by removing one step of the process.

Another activity that takes time is the adding of packing notes, being done for orders when requested by the end-customer. As a consequence, the correct package has to be identified by the packer, controlling that the notes are being placed in the carrier with the same order number. Additionally, another label has to be placed on these packages, to inform the receiver that it contains a pack note. An additional problem that could be identified during the observations was that all shipping labels had to be reprinted at the packing station, resulting in the packers having to walk along the roller belt to scan the picking labels, then go back to the printer to collect shipping labels, and again go along the belt to attach the shipping labels to the boxes. This in combination with the need to fill boxes with filling material leads to a lot of movement for the worker, consuming a lot of time. In some cases, the extensive process leads to the roller belt becoming full, hence forcing pickers to place packages either on the floor or nearby benches, increasing the amount of work having to be done at the packing station at a latter stage when the packages need to be moved an extra distance.

Even though these activities are not directly connected to fill rate they can be seen as unnecessary. The packing note could be sent as an electronic file and the shipping label could be combined with the label used in the picking process and thus remove these steps in the packing process. Both these solutions are deemed possible since they are used for other customers at Schenker. If these steps were removed, the activities related to fill rate would be an even greater part of the packing process making these activities even more important for the overall efficiency of the process. The trade off mentioned earlier between efficiency and fill rate would also have an even bigger effect on the total packing time and possibly decreasing the amount of boxes that are cut down.

5.1.2 Large product pick

The following section will present the findings from observations, measurements and interviews performed at Customer A's large product pick, i.e. the flow handling larger items.

5.1.2.1 Fill rates

The second flow, containing larger items, has similar problems as the small order flow. Overall, the fill rates in the packages are low, especially the weight fill rate due to the fact that many of the products are quite big and have ungainly shapes, while not being heavy, which result in few products and low weight in each box. The problems found at the small product pick are also present at the large product pick, however having slightly different impact on the fill rates. Another factor that was found in the large product flow is that some products are being shipped in their original package, thus not needing a load carrier. The overall fill rates for the large product pick can be seen in table 5.4.

Table 5.4: The average fill rate for packages in the large product pick

Fill rate measurement	Fill rate (%)
Volume	63.5
Weight	35.5

In the large product pick the the average number of products in a box are much lower than for the small product pick and a lot of packages only have one product in each box, which can be seen in figure 5.4 where around 5500 boxes are boxes containing only one product. This is an effect of the products in this product flow being much larger while the boxes have the same dimensions as for the small product pick. However, due to the products being larger both in volume and weight the fill rate is not affected as much, especially the the volume fill rate, by orders having few products. The fact that the products are larger also reduce the negative impact of products with odd-shapes, since the fill rate in orders containing these products in many cases becomes quite high even if the odd-shaped product is combined with only one other product and the fact that the odd-shaped products are larger themselves as well. In figure 5.3 it can be seen that the correlation between the boxes mostly used for odd-shaped products, C6 and A2, and lower fill rate is not at all as clear as for the small product pick. Nonetheless, it was observed that when the odd-shaped products where shipped alone the boxes are poorly sized and the fill rate becomes low.

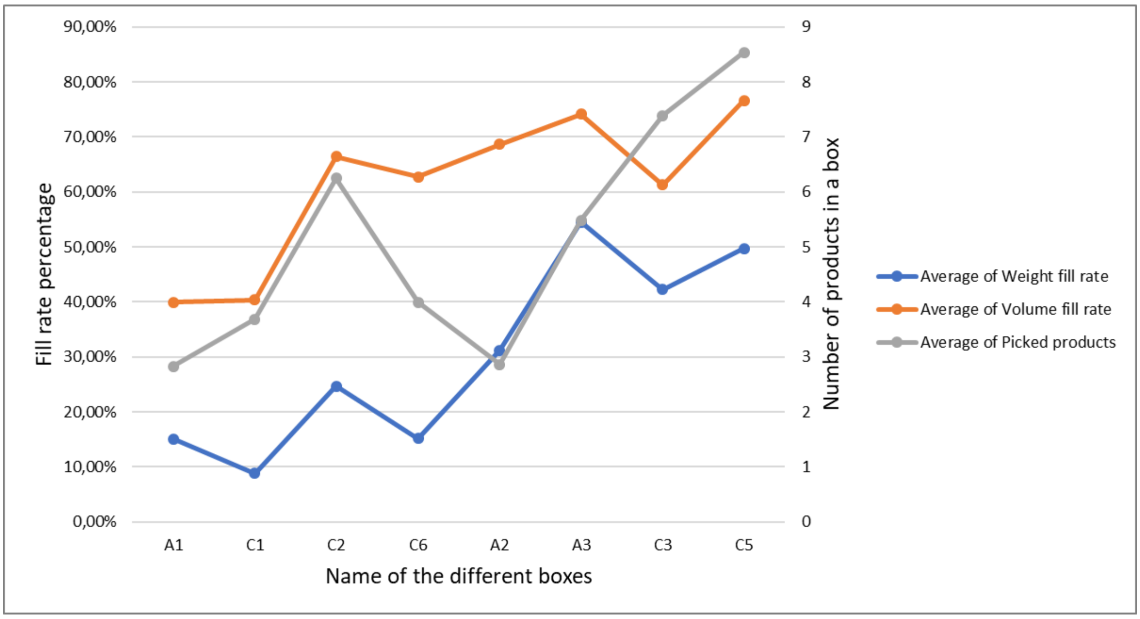

Figure 5.3: The relation between fill rate and number of products for the eight different boxes, smallest volume to the left, used at the large product pick

As mentioned the fill rate in the large product pick is not as affected by the number of products in an order, however it can still be seen in figure 5.4 that more products result in higher fill rate. The limiting factor for the large product pick is, according to observations and secondary data, in almost all cases the volume of the products. This can be seen in figure 5.3 where the volume fill rate is higher for all the different boxes and in figure 5.4 where the volume fill rate is higher than the weight fill rate for all number of products in a package. Even if the orders only consist of the smallest products in this flow they are still to big and ungainly shaped to be combined to maximize the volume in a way that make the boxes reach the weight limit. The same distinguishable correlation between the boxes used for odd-shaped products and low fill rate can not be seen either, indicating that the order composition is not as important in these cases either when the products are larger.

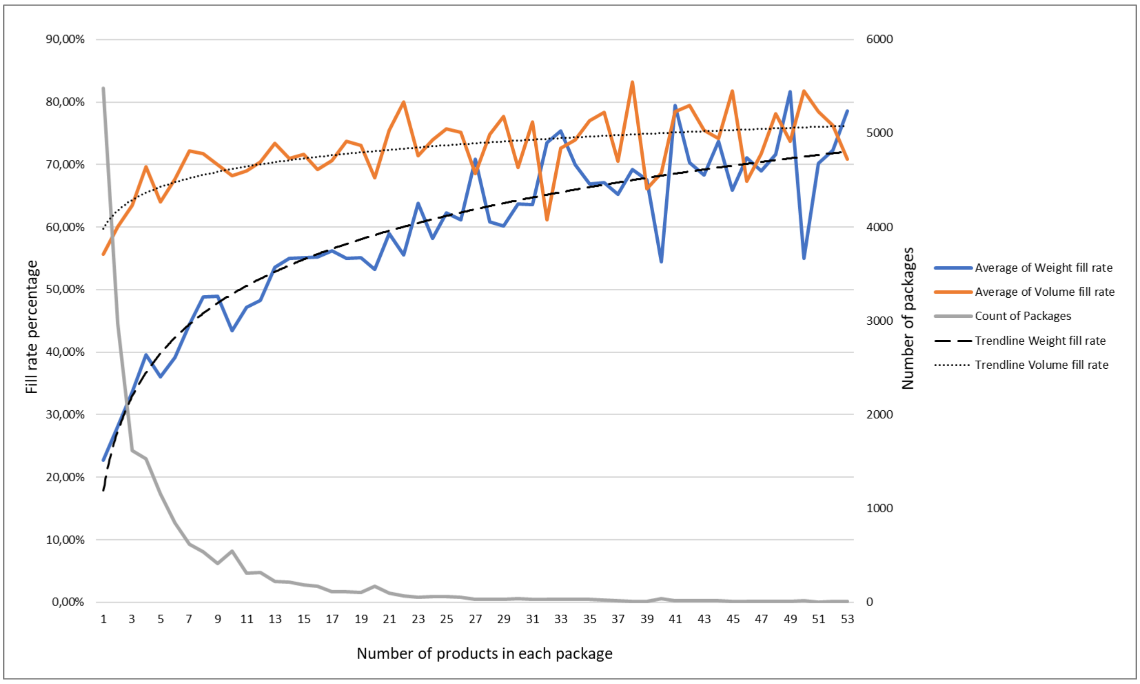

Figure 5.4: Fill rate in relation to number of items in a package for Company A

According to secondary data from Schenker around 5.0% of the total amount of orders are shipped in their original package, this is only possible if the order contain 1 product, at the large product pick, thus not needing a load carrier. Which means that they are assigned a fictional load carrier in the IT-system that has predetermined weight of 1 kilo and volume of $0.01 \times 10^{-3} m^3$. The average weight and volume of these products are 11.9 kg and 0.075 m^3 respectively, which indicate a big discrepancy between the real product and the fictional load carrier. This leads to the actual volume of the package and the volume it has in the system does not match. Currently products are only shipped in their original package if they are to big to fit in any of the boxes available at the large order pick. Beside the discrepancy in the IT-system it also creates problems in the stacking of products, since the shape of original packages does not necessarily match the shapes of the secondary load carriers used at the company. Resulting in them being harder to combine on a pallet to gain a satisfactory fill rate on a tertiary level. However, the possibility to use original packages decreases material use, as no additional carrier has to be used, and leads to 100% fill rate on a secondary level. Additionally, for these boxes, no taping has to be done during the packing, decreasing the throughput time, thus increasing efficiency. In some cases, it was noticed that the primary packages had to be cut down open to put in a pack note. This took time in itself, and forced the packer to tape the package again.

When stacking goods, the high flow of packages allow different sized boxes to be packed on different pallets to ease the process and achieve a higher tertiary fill rate than otherwise would have been possible. The boxes are divided between four pallets where two of the pallets have big boxes on them, in two different patterns to fully utilize the space on the pallet. The third pallet contains smaller boxes that can not be combined as easily to make use of the available space on the pallet, resulting in more time being spent on sorting the boxes to make them fit well together. On the fourth pallet, odd shaped goods that is shipped in their original packages are stacked, often resulting in low fill rate on the pallet since the shape of these packages are often irregular. This system result in a process where it is easier to achieve high fill rates on the pallets, as long as the volumes are large enough, however creating a lot of walking for the worker since the pallets have to be spread further away from the packing station than otherwise necessary if fewer pallets would be used, causing a direct conflict between fill rate and efficiency.

5.1.2.2 Efficiency

The table below presents a number of data points that corresponds to the time spent on performing the different activities at the packing station, presented in table 5.5. As can be seen, when needed, similarly to the small order flow, cutting down boxes demands a considerable amount of time. Unlike the small product pick no repacking was performed at the packing station in this flow. The fewer number of products is the main reason that no repacking was needed since fewer products are easier to combine in a satisfactory way for the picker.

Table 5.5: Average time per package for the packing processes for Customer A's large product pick

	Average (s)	Share of packs (%)
Scan	6.2	100
Attach label	7.7	100
Add packing note	8.1	69.1
Attach red label	4.2	69.1
Cut down	15.5	13.7
Packaging material	7.6	60.3
Tape	19.2	100
Stack	12.4	100

Another timely activity is adding packing notes to some boxes. This is something that is not done in every box, but only when requested by the customer. However, as the notes have to be matched with the correct box, the order numbers on the note and box has to be the same, requiring the packer to check each and every box scanned until the correct box has been found. This decreases the efficiency of the work, only providing value adding work for the boxes supposed to contain a pack note. Neither does the red labels to indicate that the package contains a shipping note provide any direct value while being time consuming.

Additionally, the taping of boxes in this flow takes more than twice the amount of time compared to the small order flow. What could be seen during the observations was that the size of the box makes it harder to handle, being an explanation for this. Even though the boxes used in the both flows have the same volume the majority of the boxes used at the large product pick are the larger boxes while for the small product pick it is the smaller boxes. The distance that has to be covered is also a factor that impact the total time it takes to perform all the activities, including the taping. Distance is also something that affects the time it takes for the printing and attaching labels, put in package material and to close the boxes, increasing the resources needed. Especially the scanning and printing of labels required a decent amount of time, as the packer always had to make sure that the printing was done correctly, so that no package was missed in the process. Similar to the small product pick it is deemed that the packing note could be sent electronically and the shipping label could be combined with the picking label.

Occasionally, items packed in a non-suitable carrier, i.e. when a product do not fit in the carrier it has been picked in, have to be moved to another load carrier at the packing station. This creates non-value adding work and consumes time from performing the standard routines, sometimes creating delays later in the flow, due to the extra activity taking more time than balanced for. Even though performed, as it is a necessity, the change of box is not always translated to the IT-system as it is a timely process, resulting in the same problem as for original packages where the actual volume of the package does not correspond to the volume of the package in the IT-system.

5.2 Findings for Customer B

This section will present what was found during the studies of Customer B. As the company has two separated flows, which where studied individually, the results will be presented accordingly. A more detailed description of the company and its flow is presented in section 4.2.2.

5.2.1 B2B Flow

The following section will present the result from the studies performed at Customer B's B2B flow, i.e. the orders going to stores owned by the company.

5.2.1.1 Fill rate

According to calculations made on the process, the average fill rate in the packages are 87.0%, with the median being even higher at 92.9%. These calculations where made with secondary data from Schenker, filtering and excluding data that would skew the results as they had unrealistic values in the data set. Overall, these are high fill rates, which matches the observations made on the flow, where a lot of packages was on the limit to overfull and in several cases needing repacking.

A summarization of the total number of packages sent during the study period is displayed in figure 5.5. This graph shows the total number of packages on the right y-axis, the fill rate on the left y-axis, and the number of products per package on the x-axis. This shows the correlation between increasing the number of products per box and how it seems to increase the fill rate in the packages. Additionally, with the IT-system being set to have fill rates up to 96%, the data matures around this number, indicating that the fill rate does not increase drastically over a certain number of items. However, when having a low amount of items, the fill rates fall way bellow the goal in a rather large amount of cases. If connected to the observations made on the flow, these cases are most probably overrepresented by being the last box in different orders, which contains all items not fitted in former boxes, leading to low fill rates.

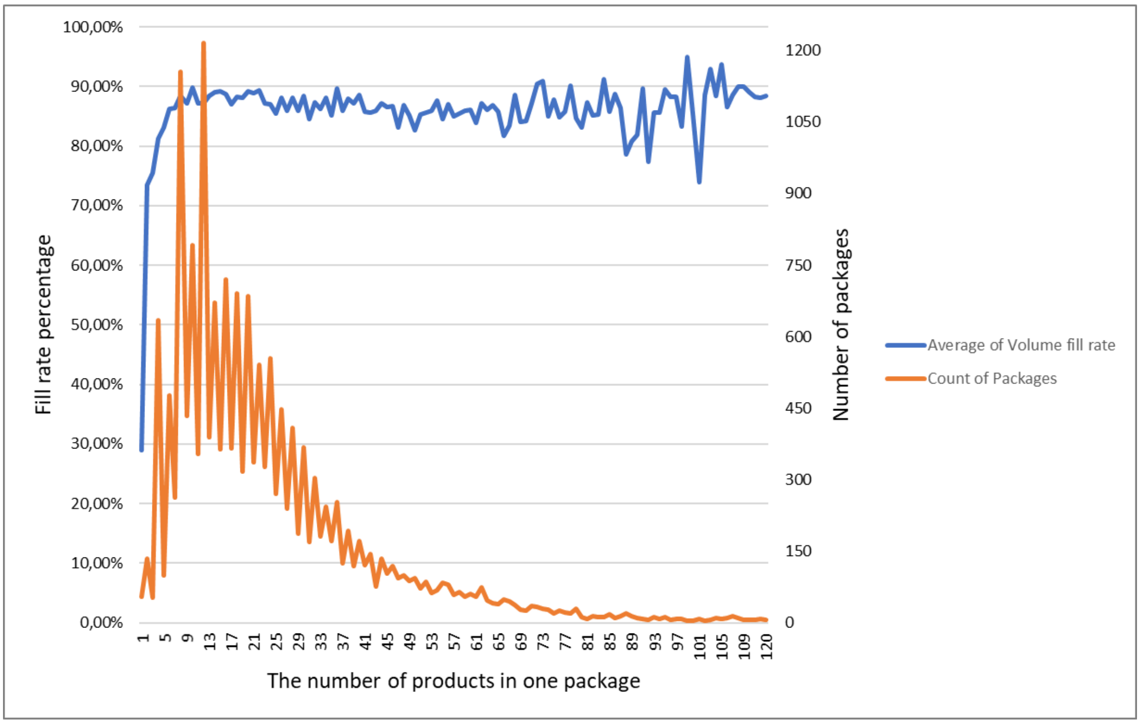

Figure 5.5: Fill rate in relation to number of items in a package for Customer B's B2B flow

The main problems observed during the packing process was the fact that around 20% of the boxes that had been packed by a picker and arrive to the packing station, were either packed in a way that made the box appear full and thereby being hard to close, or have a fill rate that is too high, creating the same problem. The former seems to origin from either the packing being done in a way that does not fully utilize the space in the box and having products sticking out, leading to the workers at the packing stations having to repack the products, or that the characteristics of the products consolidated makes it hard or even impossible to structure the items efficiently. When this is the case, unnecessary time has to be spent on either repacking or on the extra effort of closing the package. In rare occasions, it is necessary to create a lid to be put over the box, being a time consuming activity, only being necessary because of the load carriers being overfull and not able to be repacked in a way so the products fit in the box. On the contrary, it could be observed that the opposite problem, i.e. when having boxes with lower total volume than available in the box, also demands more time to be spent, but instead cutting down the boxes to decrease the volume of the load carrier, resulting in a higher fill rate.

5.2.1.2 Efficiency

During the measurements made, the observations and time study showed that about 21.1% of the packages arriving to the packing stations needed repacking. The share of packages needing additional work and the increased time for these activities can be seen in table

5.6. This number changed during the time of the study, with a higher degree of repacking being performed by the picker later during the measurements, which resulted in fewer repacks occurring at the packing stations. In a regular case, the time to close a box was approximately $18s$, not needing any extra activity to be performed. When repacking had to be done, the time tripled, with an average time of $53.4s$. With almost a fifth of the packages needing to be repacked, and having a flow of around 600 boxes per day during the study period, increase the time spent on packing by almost $75min$ per day, as per equation 5.1.

$$T_1 = 0.211 \times 600 \times (53.4 - 18.0)s = 4481s \approx 75min \tag{5.1}$$

Table 5.6: Times to close a box

	Time per pack (s)	Share of packs (%)
Regular	18.0	66.6
Repack	53.4	21.1
Cut down	42.3	12.3

The packing times also increase when having to cut down the boxes, which was done in 12.3% of the cases. This activity takes around $42s$, thus increasing the time to perform a pack by approximately 30 min per day, which is displayed in equation 5.2. On the contrary to the repack, cut down is not necessary, but instead something that should be performed to improve the fill rate. As a consequence, the amount of cut down packages varied between 7-24% depending on the packer, with some workers being more meticulous.

$$T_2 = 0.123 \times 600 \times (42.3 - 18.0)s = 1793s \approx 30min \tag{5.2}$$

The current work routines places the responsibility to repack the boxes on the pickers, so that when boxes are placed on the roller belt, the packers are exempt from this activity. However, as the activity is not easily done during the picking routes due to limited reach, many boxes are repacked in close proximity to the packing station after the picking round is completed, but still done by the picker. Hence, a lot of time is being spent on activities that are not value adding, slowing down the process and increasing the work load and man hours needed, regardless of where the activity is performed. With the trucks being a scarce resource, which should be utilized to as large extent as possible, it could be argued to create costs when these are standing still while the picker repacks packages. Additionally, in some cases when several pickers arrived simultaneously, trucks blocked the way of other workers, which created delays in the flow.

Additionally, as the picking is done in batches of six, the orders arrive to the packing station accordingly, creating a varying work load on the stations. As a result, the handling and stacking of packages are done in batches, i.e. handling multiple packages in a row for one specific activity, sometimes leading to the roller belts becoming full. On such occasions, boxes are placed on a third roller belt that is positioned less convenient for the packer, which result in that the packer have to walk to the third belt to handle the boxes, and then cover a longer distance when stacking the boxes, creating unnecessary movement.

5.2.2 B2C flow

The following section will present the result from the studies performed at Customer B's B2C flow, i.e. the orders going directly to customers or to customers through stores.

5.2.2.1 Fill rates

A majority, almost 70%, of the packages are packed in plastic bags. In other cases, if not packed in a plastic bag, a variety of boxes is used. The shares of each of these are presented in table 5.7. For this flow, two standardized boxes was available, however, also including a random number of empty primary boxes that is saved by the pickers. Foremost, the reason for this was that the products sometimes had bigger dimensions than any of the standard boxes. To cope with this, the packer would collect a leftover box, being located at a separate place from the picking stations, demanding time to be spent to cover the distance and to actually decide which box to pick, creating their own solutions for each order through secondary process thinking.

Table 5.7: Shares for each packing type

	Amount	**Share of packs (%)**
Plastic bag	251	68.2
Box	103	28.0
Special pack	14	3.8

The plastic bags could be considered to have a fill rate of almost 100%, since they do neither take up space nor contain much air. Because of this, the bags are used to as large extent as possible, whereas boxes are only used when necessary. In the boxes, the fill rate is often quite low. The reason for this is that many products that has to be packed in a box are fragile items that need to be wrapped in protective material (bubble wrap), taking up space in the packages. In many of the cases seen, the workers extensively used the bubble wrap to ensure themselves that the product was proficiently protected. Since there is no standard process for the use of protective material, the amount of protective material used is dependent on the individual packer which in many cases use what seem to be an unnecessary large amount of protective material. This drastically increased the volume of the product, demanding a lot more space for each product wrapped, resulting in the packages containing a lot of air.

Furthermore, as a part of the e-commerce orders are delivered to customers through stores, orders being shipped to be picked up at the same location are consolidated to simplify the transportation and decrease costs. This adds another element in the packing, as additional boxes has to be built and items already packed once, are packed again. This is a result from Customer B demanding consolidation to be done, and the online part of the chain being open for orders until 1 P.M., preventing this activity to be done straight away. Before 1 P.M., the items are therefore sorted and stored, taking up space by the stations and adding more movement to the work. This also results in some packages being sent with lower fill rates than before consolidation, as the combination of several orders in basically any case leave out space in the load carrier.

5.2.2.2 Efficiency

For the online flow with B2C-orders, the fact that the picker has to choose the load carrier increases the complexity in the packing. Nonetheless, the number of boxes that can be used to pack items are seemingly too few, as a consequence, a part of the packages have to be packed in custom made load carriers. These are for example left over primary packages from the picking, or adapted solutions to fit the items for an order.

Additionally, with the plastic bags being used in a majority of all cases, see table 5.7, it allows these orders to be transported in packages that barely affect the shipped volume in relation to the total volume of the items it contains, resulting in high fill rates. However, as this kind of packing does not provide any protection, it does require the items not to be fragile. In some cases, the items in an order can not be packed in a plastic bag due to its size and shape, also forcing the packer to use a box instead. Furthermore, the amount of different load carriers sometimes creates uncertainty of which carrier to use, especially since the system does not provide any recommendation, but it is up to the packer to choose load carrier based on estimations of volume of the goods and experience. This hesitation, and in some cases the selection of a non-suitable carrier, takes extra time.

Table 5.8: Times to perform different packing routines

Times	Time per pack (s)
Plastic bag	47
Box	143
Special pack	135

As mentioned, a majority of all orders are packed in plastic bags, which is by far the most efficient way to handle an order while also achieving a high fill rate. These only takes on average 47s to pack, which is time saving in comparison to cases when it is not possible to use a plastic bag. When this is the case, the time to pack an order increased to $143s$ on average if packed in a standard box, whereas $135s$ for a custom made load carrier, as can be seen in table 5.8. The main reason why the custom made load carriers take shorter times than the standard box is because the custom made load carriers, in almost all cases, only contain one product while the standard boxes contain several products which often have to be protected by bubble wrap. Since the use of bubble wrap is a time consuming activity the total time for these orders increase significantly. However, there is a distinct difference between packing in a box and in a plastic bag, where the latter is way more efficient. This can be seen in the calculations below, where T_3 shows the increased time to use boxes and T_4 shows the increased time to use custom made load carriers each day, where 405 is the average orders packed at the e-commerce flow each day. The difference in packing time per packing alternative and day, giving a hint on how much time that is saved when using plastic bags. One of the main reasons for this is the fact that the boxes has to be mounted together before usage, and the products it contains often require protective material, i.e. bubble wrap. While the custom made load carriers has to be created by the packer each time, both taking extra time while the packer is figuring out the best solution to pack the product and when the packer has to walk to retrieve the material necessary to create the custom made load carrier.

$$T_3 = 0.28 \times 405 \times (143 - 47)s = 10886s \approx 181min \tag{5.3}$$

$$T_4 = 0.038 \times 405 \times (135 - 47)s = 1354s \approx 23min \tag{5.4}$$

Compared to the B2B flow at Customer B, the packing stations are stationary for the B2C, resulting in the packages having to be manually moved from the picking wagons to the desk by the packer. With the limited space on the stations, this means that one order is handled at a time, creating unnecessary movement between the picking wagon and the packing station for every performed order. Similarly does the consolidation inflict a lot of movement, as the packages are collected and distributed to the consolidation locations separately. To save time, this movement is often done with as many packages as possible, to increase the efficiency leading to packages being temporarily stored at the packing tables and taking up space.

5.3 Findings for Customer C

Even thought there are several different order flows, the packing is done at the same station for all flows, however with a bit varying routines depending on the customer and product characteristics, as described in section 4.2.3. The products handled for Customer C is of lighter nature so the weight in the packages are not considerable when discussing fill rate, and thus is the only fill rate measurement used for Customer C the volume fill rate.

Due to incorrect data in the system regarding volumes of the products and design of the process where there is no data gathered on which load carrier the orders are shipped in the fill rate has not been possible to calculate for Customer C. However, during the observations it the fill rate was deemed to be unsatisfactory, this observation was confirmed during the semi-structured interviews performed with employees working at the process. The reason for the low fill rate is mainly because of the size of the load carriers being to big and the number of alternatives of load carriers being to small. This is however nothing that Schenker can control since it is Customer C that decide what different load carriers Schenker are allowed to use.

Most of the products handled at Customer C are soft products that are not fragile which indicate that these products could be shipped in plastic bags to both increase the fill rate in the packages and the efficiency at the packing station instead of the boxes used today. However, boxes are used since it, at the moment, is a requirement from the Customer to convey a premium feeling. There are also some fragile products that are not possible to ship in a plastic bag but still sturdy enough to not demand any protective packaging material more than the boxes used today.

There are some general problems in the packing. One of them is the fact that the products arrive to the stations in boxes that are not used for further shipment, leading to the products for each order having to be moved from this container into a load carrier. This does also affect the return flow of the boxes, as they sometimes could be in the way of the workers when stacked close to the stations, simultaneously affecting the efficiency as they have to be moved away occasionally.

Another problem identified during the observations, which was validated during the interviews, was the load carrier quality. With the flow being designed to have boxes suitable for strapping, the load carriers have to be resistant enough. The problem occurred when the customer started to order boxes of lower quality, with the consequence that the boxes broke during shipments, resulting in customer complaints. Instead of using better carriers, the customer requested the boxes to be taped instead, which created unsolicited work at the packing stations, especially since the flow has been designed to strap packages.

In contrary to the other customers studied, the stacking of packages are separated from the packing stations, being a floor down. As the volumes are too low in this flow, having a worker only working with stacking products would result in very low resource efficiency, as there would be a lot of waiting time. Since the scope of the thesis only include the work done by the workers at the packing station this activity has not been analyzed, and thus is the impact this has on both the efficiency and the fill rate on a tertiary level not evaluated further.

5.3.1 B2B flow

The B2B flow, i.e. MZ1 and MZ2, involves the shipments going to stores. Generally, these shipments consist of larger amounts of goods since the stores often order in batches or many different products at once. This is beneficial when the items are soft and can be packed densely without risking to damage the products. However, some of the items are of more fragile characteristics, thus requiring more careful packing, for example items that has to be hung instead of horizontally packed.

Even though the orders are bigger in the B2B flow the fill rate is still quite low. The two boxes that are used in most of the cases, for the products not shipped hanging, are quite different in size where the smallest is box is to small for a majority of the orders. Thus is the larger box needed, but the orders are rarely big enough to fill out this box resulting in low fill rate.

Some customers in the B2B flow has special requirements for the shipments going to their stores. This is foremost to sort items based on style and color. As a result, many orders have to be split into two different boxes. This creates extra work at the packing, as more load carriers have to be used, going through the standard activities more than once for a single order, including manually splitting the order in the IT-system, print extra labels, and tape all boxes. This increases the time spent and material used per order, also creating the risk of packing items in the wrong box.

Another problem that could be identified was the packing of items that has to be hung on hangers during transport. To begin with, these boxes are too big to be handled at the packing stations, forcing the packers to mount them together next to the station on the floor, taking up both space and extra time. Furthermore, the products can not be packed as densely in the boxes compared to horizontally stacked orders, i.e. the goods take up more space per product, resulting in low fill rates in these packages.

5.3.2 B2C flow

Problems identified for the end-customer shipments, i.e. MZ3 and MZ4, does foremost derive from requirements set by Customer C. These requirements involves, for example, wrapping the product in paper and adding a delivery note to each package. As this has to be placed in the package, it sometimes leads to the worker having to wait for it to be printed, before being able to attach shipping labels and closing the package. To cope with this, the workers perform the routines in a different order to better utilize the time, however, this affects the quality control as the counting of articles in the package is done while the items already have been packed, increasing the risk for quality deficiencies.

For the single piece flow, the fact that only one item is sent at a time creates low fill rates in the packages. Even though there are a number of available load carriers to choose from, single items does not fill out the packages. Additionally, in this flow, the system chooses the load carrier automatically, hindering changes to be made by the packer to adapt the box to its content. In combination with the lack of correct volume information in the system, this occasionally result in low fill rates.

Most single piece orders are picked in flat packages as they are the smallest load carriers available. Despite achieving rather high fill rates when used, the design of the carriers does not allow them to be transported on the roller belt as they get can get stuck. To cope with this, all these packages are gathered on a pallet and lifted with a forklift from the mezzanine to the bottom floor, adding activities to the packers and demanding time from forklift drivers.

5.3.3 Information

One of the biggest issues in the flows is the lack of correct volume and weight information in the system. This leads to the system not being able to provide legitimate information to the workers, hence, a lot of manual input has to be done. Without correct product information a process where the system choose load carrier for the order cannot be used since this will result in orders being picked in either to small load carriers, forcing the worker to switch load carrier, or to big load carriers, resulting in low fill rate. An example of the problem with wrong product information in the system is that the packer sometimes, for packing zone MZ1 and MZ2, have to choose the load carrier for individual orders in the system, increasing the amount of work having to be done in the information system. Apart from this, the faulty information prevents the flow to be designed to make use of this data, as it would show the wrong numbers, risking the company to be punished by freight forwarders if the numbers do not add up.

Additionally, for orders being shipped with two specific freight forwarders, information about weight and number of packages has to be provided. At the moment, with the information in the system not always being reliable, packages have to be weighted, adding another activity that takes up a lot of time. The reason for this is that the shipping companies require each package's weight, not allowing only the weight for a consolidated pallet to be provided. To not risk any complications from mistakes and faulty shipments, workers has to carefully control the order to be correct before completing the order.

6 Analysis

This chapter will involve an analysis of the results compiled in the case study. This will revolve around how the efficiency is impacted by the fill rate in packages, and how indifferences in the flows seem to have an impact on these performance measures.

6.1 Fill rate

Schenker achieved varying fill rates for the different customers, depending on several factors that was identified during the study. The identified factors presented below, that influence the fill rate, will be discussed as well as similarities and differences between the studied customers related to the identified factors.

6.1.1 Product impact

One of the factors early identified in the case study was the extensive impact product characteristics have. Harder products tend to result in low fill rates, foremost due to their inability to be pressed together. In these cases, combining several items in a load carrier makes the aggregation dependent on the dimensions of the load carrier in relation to the products it contains. The aggregated study showed that many of the packages with the lowest fill rates contained at least one odd-shaped product, for example a product that is too long to fit in most boxes, which results in the load carrier being too large volume wise. This can be interpreted as if the boxes are too high compared to its bottom dimensions and the average volume shipped in the specific carrier. To cope with this, the amount of different load carriers would need to increase. Another solution would be to have higher flexibility adapt the height of the load carrier to fit the products it carry.

Worth to mention is that the B2B flow for Customer B has separated all the odd-shaped products, i.e. all products that do not fit in the standardized box, to be handled in a separate order flow. Which can be seen as one of the factors to the high fill rate in this flow since a bigger load carrier do not have to be chosen because the characteristics of one product. To compare, Customer A has separated a part of their flow, isolating the hardest products to pack. However, the product range is larger for Customer A, making it harder to separate all odd-shaped products. This means there are cases where the products does not fit in the assigned load carrier or that a larger load carrier has to be picked, questioning whether these products should have been identified and preferably handled in a separate flow as well.

Additionally, not separating the odd-shaped items seems to create disturbances in all flows studied. With both Customer A and B having products with these characteristics, issues appear for both packing processes when bumping into these products, generating extra work to be performed by the packers. If basing assumptions on the study made, limiting the scope to the one of the study, the efficiency could be improved if handling difficult items at a separate station, not necessarily at a different location, but at a separate packing station with adapted equipment and resources.

For fragile products, the problem appears differently, as the air shipped mainly comes from the use of protective material, taking both time and decreasing the fill rate. If looking at Customer B, this activity only appear in the B2C flow. The reason for this is that when shipping to stores, the fragile products are only shipped in batches, which means that they are picked and shipped in their primary packages, i.e. each package contains several items of one specific product type. This is possible to control in flows where the goods are shipped to stores, since Schenker and their customer can decide that these kinds of products only should be ordered in the same amount as a primary package contain. However, for B2C, the quantity ordered from a single customer can not as easily be limited, resulting in the protection used in the primary package not being available for further use to the same extent. Instead, the product has to be surrounded with new protective material, taking both time and resources.

6.1.2 Order sizes

Early on, during observations, the differences in flows indicated on an affect from order sizes. Customer B, with fairly large order sizes, both in quantity and volume, have overall high fill rates. This can derive from several aspects, but one is believed to be that the orders being delivered to stores are of large quantity, more easily filling up the load carriers, while also enabling for more products to be combined in different ways (however not necessarily doing so). This is also strengthen when analyzing the data, where the graph presented in figure 5.5 clearly shows that when having to few products, the fill rate tend to decrease a lot, especially when only having one standard load carrier in the flow. In comparison does the online flow for the same company have lower fill rates in the packages sent in boxes, with the orders most often having lower quantities. In this specific case, the company solves this by having plastic bags to ship low volume orders that do not require any protection.

In relation to Customer A, who handles different types of products, orders with low fill rates often contain a low amount of products. Theoretically, this flow would benefit from having a larger amount of items per order, since this would require boxes of larger size, both in regards to box dimensions and total volume. This would allow products with odd shapes to fit in the packages, while also increasing the fill rates. A possible solution to achieve this for Customer A is to consolidate packages from the small product pick and the large product pick which would increase the number of products in the package leading to higher fill rates. This would also mean that small and large products are mixed in the boxes which would decrease the product characteristics impact on fill rate as well. However, this solution would result in more work so the possible gain would have to be further evaluated where the trade off between fill rate and efficiency has to be considered.

On the contrary, to get back to Customer B, the issue is the opposite in the B2C flow. When handling orders that contains a higher amount of goods, apart from fragile products, the pack can not be done in plastic bags. Instead, boxes are used, which leads to lower fill rates. That is to say the fill rate is often better when having lower volumes and fewer products, as long as the items can be shipped in a plastic bag.

6.1.3 Order balancing

For Customer B, the most time consuming activities are the repacking of items in a load carrier so the products fit in the load carrier, or cutting down the boxes to decrease the load carrier volume to better fit the volume of the products it contains. In the data studied, most boxes are filled to a high degree, however with a number of boxes not being possible to reach as high fill rates. In many cases, this seem to be a consequence of the order sizes, being either too small to fill out a box solely, or that one full order containing several boxes is not evenly balanced. The latter might result in some boxes being overfull while the last box in the order is assigned to contain remaining products, thus resulting in low fill rate. This might be the case, since the system fills up boxes until reaching the maximum allowed fill rate, then starting to fill the next box. This thought is strengthened by the calculations of the average and median fill rates. With the median being higher than the average, it indicates that a large part of the carriers with lower fill rate than the median, is very low. While on the contrary, packages with higher fill rate than the median is limited by the fact that it does not fit in the package if too full. However, if these orders could instead be evenly balanced, to avoid the cases where unnecessary time has to be spent on the packing, the same overall fill rate could be achieved but evenly spread among the packages for the same order. At the same time, this could increase the amount of packages needed to be cut down, which also is an activity that has been identified as time consuming and should therefore be avoided.

When focusing on Customer C, this problem does not arise in the same extent. This is thought to be due to the fact that the goods are more easily combined in the packages, as they can be pressed together. Furthermore, the increased amount of load carriers makes it possible to use different sizes on load carriers depending on the size of the order. In combination with overall having smaller order sizes than Company B, a majority of orders can be fit in a single load carrier.

6.1.4 Customer requirements

Another factor that is affecting the fill rates and packing efficiency is the demands and requirements set by both Schenkers customers and end-customers. As can be seen from the study made on Customer B, the plastic bags used for shipments are both efficient to handle and results in high fill rates. Based on the results from the different customers, the amount of time required to pack a box is considerably higher than a plastic bag. Specifically for packages being of more fragile characteristics, foremost being the items demanding to be hung during transport. These does not only result in lower fill rates, but when sent in flat packages, the efficiency might be decreased due to the items having to be carefully handled. Regardless of this fact, and even though the characteristics of the products sold by Customer C are similar, but a little more delicate, to the ones shipped in plastic bags for Customer B, these kind of load carriers are not used for Customer C. Instead, boxes are used to give an exclusive feeling towards customers. However in many cases, according to an interviewee, with the material being of low quality for the load carriers, the load carriers often arrive in a bad shape and the exclusivity is not achieve anyhow. This might create customer dissatisfaction, and furthermore result in costs for items being destroyed during the shipment. This seems to be contradictory from the results, as the plastic bags have shown to be a beneficial solution for shipments, however with Customer C not making use of this, even though the flows are similar.

6.1.5 Omnichannel impact

For Customer B, the impact from having an omnichannel flow has been the most distinct. When handling the orders going to stores, Schenker has put requirements on the orders to make the process more stream lined by reducing the amount of shipments that are hard to handle. For example, by having stores only having the possibility to order some products in batches, to make the handling easier. This is possible to do when cooperating with the customer and both actors are interested to draw benefit of such a requirement. On the customer side, the same requirements can not be made. This makes the online flow harder to handle, as every order is unique, and the company can not force the customers in the same way to order a specific quantity of a product.

Additionally, all orders going to end-customers through stores has to be consolidated, by request from Customer B. This creates lots of additional work, also decreasing the fill rate. On the positive side, it decreases the amount of packages to be handled later in the chain. This is foremost a benefit that is externally profitable, thus not showing any direct positive effect on the process studied.

6.2 Fill rate vs Efficiency

The fact that achieving higher and higher fill rates tend to decrease efficiency is commonly known in the shipping industry. Focusing on Customer B, for the B2B flow, the average fill rate for the packages are set to be around 90%. In some cases when the fill rate of a package approaches that number, repacking becomes a necessity to fit all products, decreasing efficiency. With the current design of the work process, the repacking should be, but is not always, performed by the pickers before placing the boxes at the packing stations. The preferred case would be that the products could be packed ”perfectly” when picked, i.e. when first placed in the package on the picking route, however, as this is not always possible, repacking will occur somewhere in the chain, either at picking or packing. This means that the high fill rate inflicts additional waste to the process, raising the question whether it is too high to be considered efficient. A possibility could be to decrease the fill rate by for example 5%, to study the difference in repacking time and how often it has to be done in relation to the original state. In theory, this would increase the number of boxes needed to transport a volume of X m3. However, as most orders are large enough to be divided into several boxes, many of the last boxes filled in the order have low fill rates. If this is taken into consideration, the amount of boxes should not increase considerably, while saving a lot of time and increasing the time efficiency. The boxes will have to be filled to a certain level nonetheless, since decreasing the average total volume of the products in one box might increase the number of packages having to be cut down, which would have a great impact on the efficiency, also increasing the waste of material.

The question that arises is where the work load should be added, since in some cases the added activity of repacking or cutting down boxes leads to a bottle-neck being created at the packing, whereas otherwise its more important to have a fast paced picking. This will depend on the balancing of the whole process, including both picking and packing. In the optimal process the repacking should be flexible and function as a balancing tool, where the repacking should be done by either the picker or the packer depending in the current workload. However, regardless of where the repacking is included, the current inconsistency should be dealt with and a standard process should be implemented and followed. This should enable further and more precise studies on how the repacking activity could be used to balance the workload in an efficient way.

The most natural comparison to this is Customer A, looking at both their flows, i.e. B2B and B2C. Customer A's and C's flows are similar, but with some differences that seem to create a great variance in performance and throughput time. At Customer A, greater focus is placed on ensuring a safe transportation for the products shipped, as they are of more fragile nature. However, the fill rates in these packages are low, as the dimensions of the boxes and products does not seem to correspond. This inflicts additional activities concerning the filling of load carriers to protect its content, or to decrease the volume of the carrier through cutting down the boxes. Filling the boxes is a necessary activity, since it ensures a safe transportation, but it does not improve any of the performance measures that has been studied. On the contrary, it especially decreases the efficiency, neither improving fill rates of the packages when filling them with packaging material.

When it comes to Customer C, the fill rates vary depending on the type of shipment. With the products distributed being mainly textile products, the efficiency does not seem to be correlated to the fill rate in as large extent as the other customers. Instead, it is rather, as mentioned, the impressibility of products that impacts the efficiency, and the fact that the load carriers can be adapted to the order size to a good extent.

6.3 Layout indifferences

The layout is important when it comes to create an efficient flow without unnecessary transportation of the goods and other related movements performed by the worker. The layout for Customer A's flows and Customer B's B2B flow are similar, with roller belts that carry the packages, enabling easier and faster handling of goods, hence increasing the efficiency. When comparing to Customer C, the roller belt is a common factor, however the packages have to be manually moved from the belt to the working stations creating unnecessary motion in the process, contributing to wasteful work being performed. Additionally, this requires more space to be reserved for the stations. Furthermore, as the picking and packing is done in different boxes, i.e. they arrive to the packing stations in different boxes than they are shipped away in, also adding activities that does not provide any value to the end-customer. Instead, the processes would benefit from packing directly into the load carrier to be shipped in, to eliminate the extra step.

Additionally, for the large order flow for Customer A, the workers occasionally perform the tasks for a large amount of boxes at the same time, i.e. the working batches are rather large. This forces the worker to cover a longer distance while performing the task creating a lot of walking in the process, however possibly saving some time on other smaller activities. Nonetheless, this results in fewer but longer cycles, sometimes causing the belts to be full, forcing pickers to either wait for the belt to be cleared or place the packages on the floor. To prevent this from happening, the packer should perform the tasks for a smaller amount of boxes at a time. Furthermore, as there are two belts next to each other, the work area could be seen as a U-cell, eliminating unnecessary walking between performing activities. This would also limit the working area to be closer to necessary equipment. For the small product pick, the layout does not allow this kind of work setup, since the roller belts are separated. As a result, each worker only handles one flow at a time, inflicting wasteful walking. However, with the belts being smaller, necessary equipment are located so that it reaches the whole belt without any problem for the worker.

6.4 Importance of information

One of the most important assets identified during the study was the information available and shared from the customers. As the companies studied were in different stages of their operational phases at Schenker, i.e. having been fully operating for different amounts of time, lack of information occurred and impacted the packing processes differently. For Customer A, part of the packages are either cut down or shipped in its original box, which is a good way to increase fill rates and decrease material waste. However, as this information is not translated further down in the chain, the benefits gained are harder to track, not taking full advantage of actually improving the fill rates.

Process wise does Customer B handle their packages similarly, with the difference that the system is designed to calculate fill rates based on the volume of the products in a carrier, the gains can be utilized in a better way at all fill rate levels. In contrary to Customer A, this demands that the information in the system is correct for all products when it comes to volume, otherwise the operations will be prone to quality issues. For example, it could lead to the carriers being too full or empty, or have the wrong dimensions to fit the products. This is something that has occurred as a problem for Customer C, where the information is faulty, both creating issues in the current processes, but also limiting the possibilities to improve the flow. Possibly, if the information shared between Schenker and Customer C could be increased and made more accurate, the amount of administrative work could be decreased. Administrative work that would be removed or decreased is the manual input and selection of load carrier, as this could be automatically done with the system choosing a suitable carrier based on the information available. This would decrease the throughput time, thus improving efficiency.

This is related to another aspect which was discussed with one of the group leaders for Customer C during an interview, as a part of the process could be automated to strap the packages, similar to a solution at a former customer. However, this would require the information to always be correct, as the pickers would pack directly in boxes used also for shipment, similar to other flows except the e-commerce flow for Customer B, which demands that the picker knows what load carrier size to use. If this was to be implemented, it would decrease the amount of steps in the packing process, and also free up resources from the packing to be used for picking instead, basically going from having separated packing stations to packing while picking. Worth to mention is that some of the flows, foremost pointing out the ones with hanging products, will still demand time and effort to be spent to manually pack the box. However, automating a part of the flow is still believed to improve the overall efficiency of the flow, while improving the fill rates in the packages with the correct product information.

Another idea discussed during the interviews was to introduce plastic bags to be used for packing, which has been formerly proposed by Schenker to be used instead of cardboard boxes. This would most probably improve the efficiency of the flow and certainly the fill rate in the packages, thus also being positively received by the customer. Nonetheless, as the cost and new setup would inflict hard costs in the beginning, the idea seem to be stuck at the customer side. As a result, the flow is stuck with the boxes currently used, even though a lot of time and money could be saved on such an investment.

At a process focused level, some issues were identified regarding faulty information. One example is for Customer A, where occasionally, products arrived to the packing stations in load carriers they did not fit in. This resulted in the packers having to repack to product in another box, which demand extra time to be spent. If products, or load carriers, that frequently have this issue could be identified and corrected in the IT-system, time could be saved from not performing wasteful activities.

Looking from a sustainability perspective, regardless of the fact that many of the boxes shipped are cut down or changed to smaller load carriers, information is not transferred to the IT-system. This means that the actual volume shipped will not correspond with the volume shared to shipping companies, making it harder to utilize the increased space available on the pallets as it ”does not exist” according to the system. From an environmental perspective, this does not increase the overall fill rate of the lorries unless the information is shared, and the lorry can be filled with other items.

6.5 Lack of standardized work routines

For a number of the processes studied, the lack of standardized routines made it hard to measure performance and efficiency. Partially, this is due to the workers following irregular patterns, both affecting their own performance, creating a variance in their own work, and a fluctuation between different workers. Apart from this, there are no standard times to compare with, making it hard to evaluate whether they perform well or not. The processes which do have good routines that are followed by the workers, especially Customer B’s B2B flow and Customer A’s small pack, showed both higher performance and less fluctuations in their work compared to the other cases studied.

The fact that the standardized routines seem to have greater performance might be due to the fact that it is built on primary process thinking, i.e. performing tasks without actively thinking about how to do it. This way, no doubt is involved in the work, increasing the efficiency and having a more even work pace. If improved, this could make it easier to balance the flow, thus making better use of available resources. On the contrary, when the routines deviate, and solutions have to be made based on specific prerequisites, the workers engage more in secondary process thinking. The workers then has to be more active in their choices on how to find a solution, increasing the time needed to perform activities and decreasing the quality of the work. This could also be seen in the cases with new workers, especially with Customer B being a new customer to Schenker. The activities was performed with lower efficiency for these workers, as more active thoughts needed to be engaged, decreasing the efficiency, especially in combination with customized solutions. This emphasizes the usefulness of adequate work instructions. Additionally, activities that require the worker to engage more in secondary process thinking should be handled by workers that can manage them on intuition.

During the case study, the share of packages being cut down at the B2B flow for Customer B, presented in table 5.6, varied a lot depending on the packer. Whereas most workers only cut down when necessary, especially one packer cut down as often as possible. This led to a lot of time being spent on this activity, in the end not resulting in that big improvements, as each box was only cut down a bit, in total not saving enough space to increase the number of boxes that fit on a single pallet. Especially due to the packers deviating from routines, as some did not cut down at all.

6.6 Limitations from running outsourcing logistics

In all processes studied at Schenker, there is work to be done that could improve, however, as the focal company is working within outsourcing and contract logistics, the available room for improvement is limited. Due to the fast paced changes from having frequently changing customer, the processes at the facility is changing as rapidly. As a result, improvements to one specific process can only be done if monetarily profitable for the contracting period, both for Schenker and their customers. This means that even though an investment is believed to improve a process, the payback might not be fast enough. Optimization of specific processes should therefore be made if necessary and believed to either benefit the company on a short time span, or if the improvement is general enough to be used for any future customer.

Furthermore, to be able to make improvements, cooperation between the focal company and its customer is of importance. As identified in the case of Customer C, there is possibilities to improve the flow, however being obstructed by the customer not wanting to invest in the suggested improvement, or the changes being of lesser prioritization at the customer side. Hence, even though a change is financially motivated, temporary solutions might have to be implemented, taking both time and being costly for the focal company and its customer.

6.7 Sustainability - Triple Bottom Line

When it comes to sustainability terms, the fill rate has been described as an important part of the transportation of products. For the companies studied, the degree to which high fill rates are achieved varies a lot. It has already been presented that fill rate and efficiency are important terms to compare when evaluating economic gains. These however, have different impact on sustainable aspects. Focusing on the environmental part of the triple bottom line, the transportation corresponds to a large part of emissions in a supply chain, hence, the fill rate of the packages every vehicle contains become an important benefit that can be gained. Higher fill rate in the packages leads to less unnecessary volume being shipped, most often in the form of air or package material, thus decreasing the total need for transportation. Additionally, the fill rate of packages could be economically sustainable since less material would be spilled, saving money for the company.

Furthermore, as plastic is known to have a big negative impact on the planet, the use of the plastic bags could be questioned. This would require the positive impact from having more efficient transportation to be compared with the possible negative effects from an increased use of plastic. This could also be a question to be decided country wise, as the availability for recycling and better handling of plastic waste is more integrated in some countries. This could also be a way to improve social sustainability, as showing dedication and clear efforts to decrease the company's environmental impact could increase market shares and create value for both Schenker's customers and end-customers.

7 Conclusion & Discussion

This chapter provides answers to the research questions, and a discussion about the findings, limitations and applicability of the report.

7.1 Answers to the research questions

The following paragraphs presents the findings to the research questions formulated in section 1.3.

1. *What are the main factors influencing fill rates in distributed parcels at DB Schenker?*

To conclude, fill rate is an aspect that is pursued in most packing flows, always being in room for improvement. However, in many cases as the fill rate is optimized further, its on the cost of having an efficient flow. It creates additional activities to be performed, demanding the processes to be flexible, and requires more resources to be spent to increase the fill rate.

Another factor that could be seen to influence the fill rate was the importance of information in the flows, foremost being focused on external communication. The external information is connected to the sharing of information to cooperating actors that could make better use of improvements made on shipments, to utilize the benefits through the whole chain. Additionally, information shared from Schenkers customers created disruptions in the flows. Identified for all customers, faulty product or load carrier information inflicted deficiencies and mistakes, even affecting the possibility to automate a part of the packing processes (Company C). This seems to be a common problem when operating outsourcing logistics with contracts that limits the economical investments, both from the customer and internally.

The most tangible aspect found is the order composition in relation to the load carrier used. There is a difference in how the fill rate is affected for the customers studied, where the characteristics and number of items an order is of varying importance. However, in many cases the size and measures of a load carrier, and how well they are adapted to the products affects the fill rate. A related factor is the product characteristics of a specific flow, and how free customers are to select quantities, i.e. stores buy in bulk whereas end-customers do not.

2. *How do the main factors influence the overall time efficiency in the packing process?*

Overall, there is a clear pattern between efficiency and achieved fill rate. In all flows, activities that is added to improve the fill rate in packages affects the efficiency negatively in the flows. Even though having a positive effect on several aspects such as shipping fewer pallets, improved product protection and pallet stability, in many cases the companies do not take advantage of these benefits. Consequently, a question should be raised whether these activities could be labeled as non-value adding, especially if not fully necessary, hence argued to be removed from these flows. In the end, the economic profitability of reaching a certain degree of fill rate has to be deeper evaluated compared to its environmental gains, as the efforts for further improvements increase with higher fill rates.

Furthermore, the customers studied in the report has a varying standardization of the processes connected to the packing. In the channels with the most uniform flows, where the activities do not deviate from the routines, the flow efficiency is higher than when obstructions occur more often in the flows, and the workers has to perform more steps with greater freedom of choice. The availability to create standard routines is foremost affected by the above mentioned factors, i.e. information sharing, communication and cooperation with customers, however also being to a large extent hindered by product characteristics, requirements and the layout of the flows.

At last, as mentioned in the case study, Schenker's customers operate different type of channels with different layouts. This origins from these customers business segments, and affects the processes as different requirements are set. The introduction of online flows with direct shipments to end-customers complicates the processes, creating a greater variety and forces Schenker to make adaptations in how they handle and ship orders. In the study, this greatly seem to decrease efficiency, and overall makes it harder for to achieve a high fill rate in packages sent. However, if plastic bags are of possible use, this problem does not appear to as great extent.

3. *How could the identified factors in the packing processes be changed to increase the fill rate without decreasing time efficiency?*

A number of factors was found, which have been concluded in the former research questions, that could be of interest when making changes in the production. For these to be applicable, the context of every specific customer will have to be evaluated. To begin with, improving the information shared between Schenker and their customers could increase transparency and lead to benefits achieved in the packing processes to be further utilized in the chain, to prevent work that has been performed to not go to waste. Additionally, this could make it easier to suggest and pull through changes that could benefit both Schenker and their customers.

Another change could be to have more standardized processes, to simplify activities and decrease the amount of secondary process thinking needed amongst the workers, hence improving time efficiency in the flows. The standardization could also be done for the load carriers, especially in flows where the odd-shaped products can be separated. However, in product flows that handle many odd-shaped products a greater variety of load carriers would be beneficial to increase the fill rate. If the load carriers could be better adapted, in many cases together with the customer, the fill rates could be improved, also eliminating activities in the packing process to increase these rates. If possible, the use of plastic bags have proven to be efficient, thereby being recommended to be used to as large extent as possible.

Depending on the goal and what should be prioritized for a specific customer, a question could be raised whether it is justifiable to have a high fill rate if it means that the time efficiency suffers too much. In the cases where this is the case, minor decreases in fill rate is could increase the time efficiency to the extent that it becomes beneficial. However, this would need further measurements on the specific flow, investigating to which extent this would be applicable and profitable.

7.2 Discussion on the findings

Overall, the study was performed in a satisfactory way, leading up to results that could be related to the research questions. These questions have been answered and followed through the process, however with a varying degree of input from the different customers studied. Especially for Customer C, the lack of numerical data during the study period made it hard to draw any reliant conclusions when in came to fill rates. Further issues with this customer was the low amount of orders, resulting in a low sample size for the time measures. The combination of low sample size with high variation in the process made the numerical data unreliable and was therefore excluded from the case study, however still considering the observations made on the customer. Additionally, the fact that we were not allowed to collect data through film for this customer further complicated the data collection. As a result, the cross-case analysis did not include this customer as much, however compared to the other companies in as large extent as possible.

As the study was performed during the Covid-19 pandemic, the data gathered is known to have been impacted in different ways. While some customers was impacted more heavily with decreased sales, thus lower activity at Schenker, others was not influenced or even had increased sales during the period. An additional consequence of this was that sales through e-commerce increased, whereas store sales decreased. Nonetheless, the study has focused on gathering and analyzing representative data for the study period, including data from both before and after the pandemic started, however having in mind possible implications and influences. The result is regardless useful, as the area of study is not in a large extent impacted by sales, but numbers and values presented including daily numbers might change the precise outcome of these calculations. The pandemic also impacted the data collection as it had to be postponed, shortening the measurements in production from four to two weeks.

7.3 Applicability

In a general sense, the results found in the report is believed to be partially usable. Foremost, and what could be seen for all customers studied, achieving high fill rates will come at a cost of efficiency, as the added activities required for this adds a lot of time to the process. However, this is also tightly connected to the characteristics of the products. As seen in the study, many physically harder product require protective material and are harder to combine in a package, whereas simpler packaging solutions can be used for soft and non-fragile products, with the latter being both more efficient and demanding less space in load carriers. If this knowledge could be used and in a better way translated to an IT-system for a larger part of the customer to Schenker, not only could the three processes studied improve, but also other current and future customers. Implementing this in an early stage together with the customers could simplify launches, and provide solutions that are more profitable from the start. Collaborating closely with customers is something that is of importance when operating within outsourcing. For companies having an internally operated packing process, it can be better adapted to a specific set of products, making it hard to compare with the current case. For Schenker, new investments can not as easily be argued for with every new customers, demanding solutions to be partially based on former setups and equipment at the facility. This would not be the case for internal processes, since the product characteristics are known beforehand and does not vary as frequently.

7.4 Future recommendations

For future studies, a longer time span should be used, preferably with customers that has had operations running at Schenker for a longer time. This is based on the fact that many of the processes and operations for newly contracted companies change rapidly in early stages. Consequently, measurements might fast turn outdated and irrelevant. Additionally, as mentioned in the analysis, many of the processes might not be standardized enough in the beginning, involving more factors to be more connected to individual performance.

For Schenker specifically, further studies of possibilities to establish more standardized work routines could be a way to get rid of unsolicited fluctuations in the work, possibly also reducing mistakes and quality deficiencies. Furthermore, if information and collaboration with customers could be increased, the use of plastic bags as a load carrier has proven to be very efficient and enabling high fill rates. In current setups, only Customer C seem to have potential to make use of this solution, however in future collaborations, this solution could be of great interest. Further studies could also include improving the IT-system with a higher degree of correct data on fill rate, since it has been found that correct data and flexibility in the IT-system can have great impact on the fill rate. Both internally to increase the fill rate in packages, as well as externally if correct fill rate information can be shared with transport companies.

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A Appendix

A.1 Appendix 1

Interview questions

General Questions

- Which customer do you work for?
- What is your position at the company?
- What are your main working tasks?
  - Can you describe a general working day?
  - How well prepared do you feel for the tasks you are performing? Do you have any prior education in the area?

The packing process

- Can you describe the packing process?
  - Which are the most fundamental parts in the packing for it to be running smoothly?
  - Are instructions clear? Is there a need to know routines by heart, or do you get instructions?
- Are there standardized routines for the packing process?
  - Have you received clear instructions from the company?
  - How flexible are the process?
  - Do you follow standard routines? When? Why/Why not?
- How big impact does earlier activities have on the processes? (e.g. picking)
- Does the product characteristics affect the packing? How?
- How do you feel about the layout of the packing station?

QC/Improvements

- Do you perform any quality controls in the packing?
- Is there any part of the process you find problematic?

  - Product combinations?
  - Requirements from customer/end-customers?
  - Issues that adds activities to be performed?
- Do you have a part in improving the processes?
  - Own initiatives
  - Through the working team
  - Discussions at shift meetings?
- Have you worked with other customers at Schenker? Are there differences in the processes?

Fill rate

- How large focus do you put on achieving high fill rates in the packages?
- Which factors do you see impacts the fill rate?
  - Any factor that has greater impact than others?
- Is there any differences in the e-commerce flows compared to store shipments?
  - Order sizes? Amount of products per package?
  - Additional activities/requirements?
  - Challenges for the different flows?

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