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Identifying Pallet Management Strategies and Improving Warehouse Capacity

A Case Study of the Pallet Logistics at SCA's Paper Mill in Lilla Edet

Master's Thesis in the Supply Chain Management programme

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

A rather new area identified by managers as a potential for increasing returns has received great attention. Industry analysts predicts that approximately 450 million EPAL Euro pallets are in constant circulation in the world. Traditionally, pallets have been disregarded and perceived as a source of cost with the single mean to transport products to customers. Lately, actors in supply chains have started to perceive pallets in a total cost approach and, hence, as significant for the overall result of the supply chain. In parallel with an increased attention of the pallets importance on the supply chain performance, a shift towards an increased utilization of pallet pooling systems has been indicated. This is related to the constant increase in raw material prices as well as costs associated with repair, maintenance and recovery of pallets.

This study aims to answer two issues. The first issue relates to investigating the pallet logistics process at SCA's paper mill in Lilla Edet, which includes the mapping of flows to the Danish and Norwegian markets as well as reviewing the design of the pallet warehouse. The second issue concerns evaluating the current inspection control process related to inbound deliveries of pallets. Established standards and routines will be reviewed in order to clarify whether these are complied with.

A case study approach has been selected as a method in order to fulfil the aim of this thesis. Since a mixed methods approach is considered useful, both qualitative and quantitative data is collected. Interviews, observations and access to internal documents are the major sources of information. Further, the empirical findings were analysed based on the theoretical framework in order to provide solutions that addressed the stated issues. Improvement suggestions can be grouped in two major measures that should be considered. Firstly, three errors associated with defective pallets are correlated with the temperature. Consequently, during winter months' pallets should be stored in the pallet warehouse in order to avoid rising defect levels. Secondly, a redesign of the current pallet warehouse should be performed since the current design is not optimal from wooden pallet's perspective. Further, it should be noted that an increased information sharing between pallet suppliers and the SCA Edet mill is a huge facilitator for improving the studied issues.

Key words: Pallet logistics, pallet management strategies, warehouse capacity, reverse logistics, visual inspection, information sharing, inventory.

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Karl Abdallah

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List of Abbreviations

AfH – Away from home, a business segment defined by SCA

IDC – International distribution center

LSP – Logistics service provider

SCM – Supply chain management

1. INTRODUCTION

This chapter starts with introducing the background to the study, in which information related to the studied area and the firm where the thesis took place is presented. Further, implications on the firm's operations as a result of the studied area are discussed and is followed by the aim and research questions. An explanation of the research questions is presented aimed to provide more detailed information regarding the planned activities of each research question. Finally, the scope as well as limitation related to this thesis is identified and the chapter is concluded with an outline of the thesis.

1.1 Background

During recent years, the traditional way of conducting business has experienced a shifting trend towards increasing globalization. New marketplaces have arisen and industries have prospered which has led to a significant growth in the world trade (Hood and Young, 2000). Factors facilitating the globalization trend can be related to the use and availability of technology, fewer barriers concerning trade and investment as well as the development of communication, which has promoted the spread of knowledge (Enright, 2000). As a consequence of the globalization trend, the environment in which firms compete have changed and resulted in an increased competitiveness among firms. In order to handle the current significant competition in the market due to increased number of actors, firms have been forced to either decrease their profit margin or find new income sources (Weele, 2014). Further, the knowledge of resource depletion and the potential source of profit that can be realized by a more efficient use of natural resources has gained significant attention by firms when aiming to achieve competitive edge towards its competitors (Matopoulos et al., 2015).

A rather new area identified by managers as a potential for increasing returns has received great attention (Harps, 2003). Industry analysts predicts that approximately 450 million EPAL Euro pallets are in constant circulation in the world (EPAL, 2017). Traditionally, pallets have been disregarded and perceived as a source of cost with the single mean to transport products to customers. However, a study conducted by Guzman-Siller (2009) shows that actors in a supply chain of fast moving consumer goods perceive pallets in a total cost approach and, hence, as significant for the overall result of the supply chain. The change in perception of value regarding pallets have increased the attention aimed at this area and managers are starting to direct more focus to the reverse logistics, including the return flow of empty pallets. Thus, although pallets traditionally have been recognized as a low-cost consideration, they represent a great potential to increase the efficiency and decrease the costs for actors in the supply chain. For instance, some companies have been able to reduce costs by more than 50 percent by directing their focus on reverse logistics (Harps, 2003).

In parallel with an increased attention of the pallets importance on the supply chain performance, a shift towards an increased utilization of pallet pooling systems has been indicated (McCrea, 2016). Previously, common practice regarding pallet management strategies relate to sales of pallets between actors. Outbound flow of goods from a firm to a downstream customer is met with a monetary flow in the opposite direction, whereas the full value of the pallets carrying the goods is included. However, a constant increase in raw material prices as well as costs associated with repair, maintenance and recovery of pallets has increased the utilization of pallet pooling systems (Pierce, 2011).

Historically, articles and journals published in this area has been focused on three major topics (Elia and Gnoni, 2015). Studies related to the *design problem* of pallets have frequently been conducted, where different materials impact on the performance of material handling activities is analysed (Soury et al., 2009; Bush et al., 2002). Subsequently, several methods have been presented to evaluate different materials in pallet designs as well as methods facilitating the use of technology for monitoring and ensuring the quality of the pallets (Kim et al., 2009; Patricio and Maravall, 2007). Publications related to the *loading problem* of pallets represent the second major topic. Here, studies regarding how pallets should be loaded as well as optimization of the loading levels in order to decrease operations and transportation costs are covered (Kocjan and Holmström, 2010; Lau et al., 2009). Lastly, the third major topic relates to the *logistics system design* and covers issues regarding reverse flows of pallets as well as whether an open or closed loop logistics network should be implemented (Gnoni and Rollo, 2010; Silva et al., 2013; Kim and Glock, 2014). Further, this thesis will contribute to the area of *logistics system design* related to pallets.

1.1.1 Company description

This thesis will take place at SCA Hygiene in Lilla Edet, which is a subsidiary of the global SCA brand. The parent company operates in the hygiene and forest products market with approximately 44 000 employees worldwide. Total sales in 2016 amounted to SEK 117bn and the holding company is divided into three business areas. The *Personal Care* business area develops, produces and sells incontinence care products, baby diapers and feminine care products. In relation to these product segments, wet wipes, soap, lotion, baby oil and cotton pads are offered by SCA. *Forest Products* are comprised by solid-wood products, pulp, kraftliner, publication papers. Also, this business area supplies products to the energy sector, such as pellets and other biofuels, district heating and green electricity. The third business area is *Tissue* which is divided into the two sub segments of consumer tissue and Away-from-Home tissue (AfH). The product portfolio of the consumer tissue segment includes toilet paper, household towels, handkerchiefs, facial tissues, wet wipes and napkins. These products are marketed and sold under the SCA Hygiene Group's global and regional brands, such as Lotus, Regio, Tempo and Zewa as well as under retailer's own brands. The AfH segment comprises toilet paper, paper towels, napkins, hand soap, hand lotion, hand sanitizers, dispensers, cleaning and wiping products, sensor technology, services and maintenance for institutions and companies under the brand Tork. Further, the distribution of the tissue business segment can be divided into the three major channels of retail trade, online sales and distributors (SCA, 2017). The SCA Hygiene's mill in Lilla Edet, or the SCA Edet mill as it often is referred to, supplies the market with products related to the Tissue business area.

1.2 Problem description

Monthly, tens of thousands of pallets loaded with goods are delivered to customers from the SCA Edet mill. To satisfy this high demand pallets are both purchased as well as utilized through memberships in pallet pooling systems. As illustrated by Figure 1, pallets purchased represent approximately 33 % of the total number of pallets consumed in 2016.

According to Roy et al. (2016) purchasing pallets is more expensive than leasing through pallet pooling systems. Thus, the management's objective at the SCA Edet mill is to reduce the number of purchased pallets. However, this decision has several implications, one of which relates to the difference in time for the ordering deadline of empty pallets and the established production schedule. More specifically, empty pallets for the coming week needs to be ordered before the corresponding production schedule is set. In essence, it is not possible to use the predicted number of pallets consumed from the production schedule as a basis for the ordering of empty pallets.

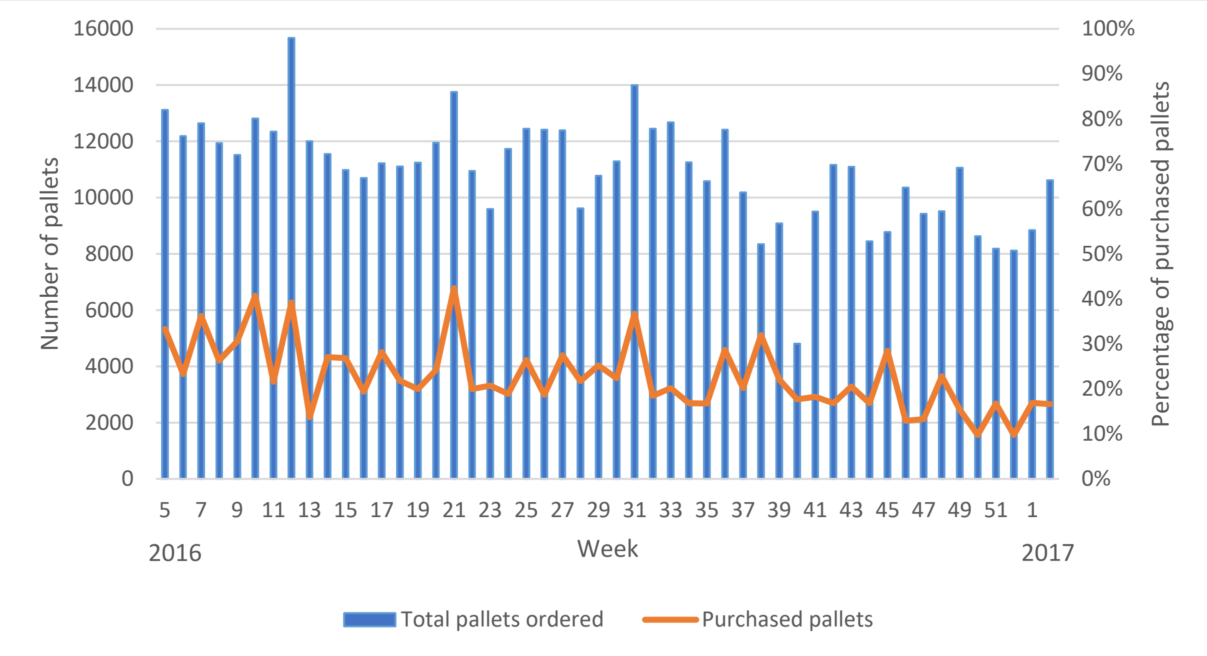

Figure 1: Illustrates the percentage of purchased pallets compared to consumption over the year of 2016.

Further, SCA has a policy stating that customers have the right to return empty pallets to the nearest international distribution center (IDC). This is illustrated by Figure 2, where the mill in Lilla Edet is represented as SCA IDC 2. The dark blue arrows aim to describe the flow of goods, while the yellow arrows describe the return flow to the closest IDC and the green and light blue arrows shows the exchange of monetary units. This granted right forces the staff responsible for the ordering of empty pallets to allow the return of pallets from customers and cover the rest of the demand by utilizing pallet pooling systems. At several occasions, the management at the SCA Edet mill experiences overflow of empty pallets due to a lack of information sharing from customers returning pallets. Consequently, pallets have to be stored outside due to the lack of storage capacity available. This outcome leads to large cost increases in the handling process, where pallets have sometimes been transported to a third-party warehouse in order to be defrosted.

When pallets are returned to the SCA Edet mill by customers or made available through pallet pooling systems they are subject to a quality control. Thus, the pallets undergo an inspection and sorting process where they are accepted, refurbished or disposed. Since customers who receives deliveries from the SCA Edet mill complains about defected pallets beyond the normally accepted levels, questions have been raised whether the quality control of arrived empty pallets at the SCA Edet mill is inadequate and if the established routines and standards should be improved.

Placed orders with pallet suppliers related to pooling systems are met with a confirmation stating the date of delivery. Thus, the planning of pallet deliveries is the LSP’s task, who usually is the owner of the pallet pooling system. This leads to that the LSP decides when to deliver pallets and the number of shipments required. Since no regard is shown to the SCA Edet mill’s preferences related to the inbound delivery of pallets, LSPs continuously deliver shipments on an irregular basis. Pallet deliveries can vary from five deliveries per day to no or a single delivery per day. Moreover, the time of delivery is not communicated between LSP and the receiving end, which further complicates the process leading to SCA Edet mill not being able to plan in advance regarding the pallet handling process. Also, the available capacity is not sufficient to handle five deliveries per day.

The same problem, related to the inability of planning their own time slots for deliveries, occurs with customers who want to return pallets. Since it is single customers who book the transports to the SCA Edet mill, the time of delivery is under the control of customers and hauler. As previously mentioned the lack of information sharing, similar to the issues with pooling systems, complicates the handling process of pallets at SCA Edet mill. Recently, the management has started to direct more focus on issues related to the pallet process. More specific, management has expressed concerns over the uneven inbound flow of pallets and a vision towards a Just-In-Time flow related to the pallet process has been emphasized.

Figure 2: Pallet process for Euro pallets.

1.3 Aim and research questions

Following the problem description an aim has been identified stating the following “*map the pallet logistics process at SCA’s production plant in Lilla Edet and evaluate the inspection control process related to the inbound delivery of empty pallets*”. The aim has been broken down into three research questions that need to be addressed in order to fulfill the aim.

RQ1. Is the current inspection control process regarding received deliveries of empty pallets complying with established standards and routines?

The first research question focuses on, as stated in the aim, evaluating the current inspection control process of received empty pallets. In order to address this issue, established standards and routines associated with the inbound delivery of empty pallets as well as the pallet warehouse will be reviewed and examined. Interviews will be held with employees directly responsible for the inspection control process of received empty pallets. The interviews should also include employees responsible of the administrative tasks related to the empty pallets. Visual inspections of the storage area as well as of the handling process will be conducted. Further, additional data will be collected from electronic files and paper documents.

RQ2. When based on actual demand, how should the inbound delivery of empty pallets be structured and managed?

To address this issue, the pallet demand at SCA Lilla Edet needs to be calculated as well as the number of empty pallets needed in storage to cover for the demand during the weekends, since no shipments are delivered during the weekends. Further, the warehouse capacity related to the staffing and inventory levels will be analysed. The solution of this should result in a suggested design of the process regarding empty pallets. Data needed to address this task will be gathered from computer files, paper documents as well as interviews.

RQ3. How is the current pallet logistics designed regarding the tissue business segment to the Norwegian and Danish markets?

To answer the third research question data needs to be collected both internally from SCA and from the SCA sales organizations in Norway and Denmark. Data regarding the invoicing of pallets to the different markets will be gathered and compiled. Also, information corresponding to the number of credited pallets related to the return flow from the different markets will be collected from SCA Edet mill. Moreover, the design of the pallet logistics will be reviewed and mapped based on information collected from SCA and third parties responsible of both the pallet pooling systems and the transportations. This research question will be focused on the design, costs and policies associated with the different flows to the Norwegian and Danish markets.

1.4 Scope and delimitations

The expressed desire, by the management at SCA Edet mill, to achieve a more even flow related to the pallet logistics defines this thesis. Focus will be directed on creating the right conditions internally in order to facilitate a future Just-In-Time flow. Studying the pallet logistics requires studying both the inbound and outbound flow since many of the pallets are often linked to return systems. However, this thesis emphasizes the inbound delivery and improvement measures will be focused at the inbound delivery of empty pallets. Nuss et al. (2015) argues that forward supply chains and reverse supply chains are to some degree interdependent which forms the basis for circular supply chain networks, as illustrated in Figure 3. According to this illustration, the scope of the thesis includes the *Distribution* in the forward supply chain and both the *Product Return Management and Reprocessing Operations* of the reverse supply chain. Further, wooden pallets are subject of this study and the pallet management strategies used in the flows related to the Norwegian and Danish markets will be emphasized. The decision to why the Norwegian and Danish markets will be highlighted in this study is based on the experienced difficulties in managing these particular flows at the SCA's mill in Lilla Edet.

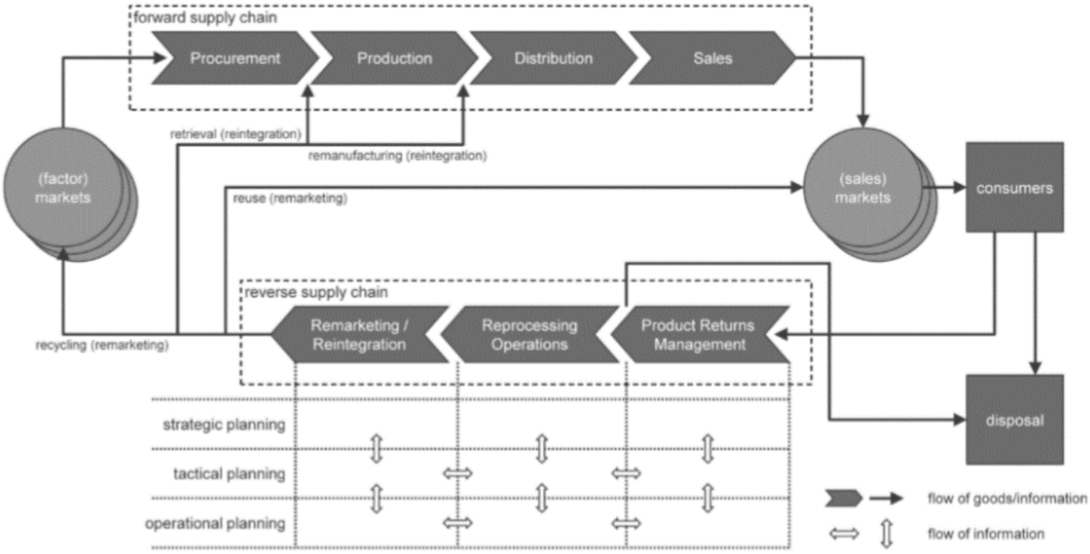

Figure 3:An illustration of a circular supply chain network as described by Nuss et al. (2015).

1.5 Outline

A brief summary of the chapters constituting this thesis is presented below, with the exception of the introduction chapter.

Chapter 2 – Theoretical framework
The theoretical framework consists of literature which the thesis has been based on. This chapter starts with discussing the reverse logistics and its relation to the supply chain. Following, the design of the reverse logistics is covered in terms of return logistics systems and pallet management strategies. Finally, quality related to visual inspection is discussed and the chapter is concluded with a section on supply chain coordination.

Chapter 3 – Methodology
The method used to conduct the thesis is presented. The research design is discussed and follows by a description of how the data was collected. Reliability and validity related to the thesis is discussed before concluding with a section regarding methods that has been used for the analyses.

Chapter 4 – Empirical findings
The empirical findings of both the qualitative and quantitative data collection is presented. Data presented in this chapter constitutes information in which the analysis will be based on.

Chapter 5 – Analysis
This section analyses the studied area based on the theoretical framework and empirical findings. Issues related to the pallet logistics process are presented and follows by an analysis of the identified improvements.

Chapter 6 - Conclusion
In this chapter, the main findings are presented by answering the research question. Future work of this thesis will be covered as well as a generalization of the results.

2. THEORETICAL FRAMEWORK

This section presents the theoretical framework and models in which the study is based on. The framework starts with introducing the reverse logistics role in the supply chain management as well as issues related to the reverse logistics. A brief description regarding the design of reverse logistics is covered which is followed by detailed theories and models of pallet logistics and pallet management strategies. The section is concluded with highlighting theories related to visual inspection and a description associated with supply chain coordination.

2.1 Supply chain management

In general, a supply chain can be described as at least two independent organizations that are linked together by material, information and financial flows (Stadtler, 2015). In practice, this statement relates to the forward movement of products and services from suppliers to manufacturers, distributors and wholesalers, retailers and finally to the end-customers involving activities of transportation, information exchange as well as exchange of funds. Accordingly, Chopra and Meindl (2016) states that a supply chain consists of several actors, as stated above. Simchi-Levi et al. (2003) support this argument by analysis of case studies showing that firms integrated in a supply chain have increased from 2,2 firms in the mid-70's to 5 firms at the beginning of the 21st century. Moreover, the three flows of material, information and finance are not single downstream or upstream flows from supplier to end-customers. Instead, a supply chain consists of both divergent and convergent flows between the different actors resulting in a more network based structure of the supply chain, as illustrated in Figure 4 (Simchi-Levi et al., 2003).

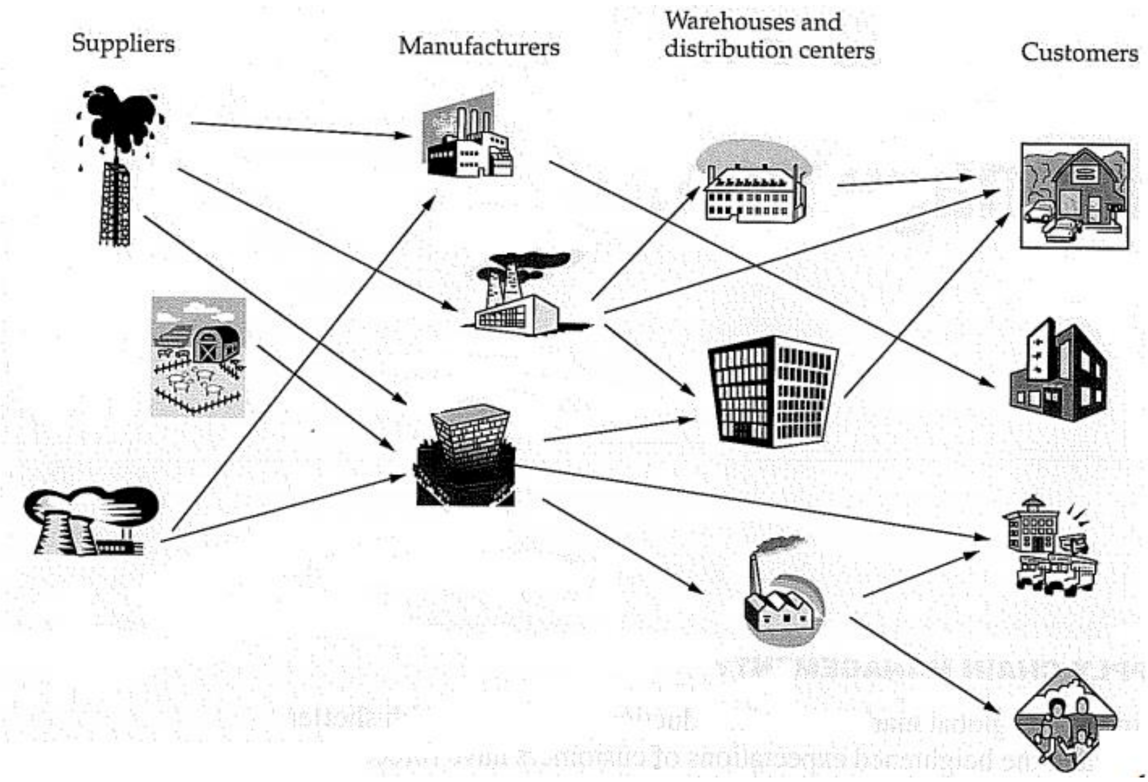

Figure 4: Illustration of a supply chain network (Simchi-Levi et al., 2003).

The overall objective of a supply chain is to maximize the supply chain surplus, hence the profitability of an individual stage in the supply chain will not result in a maximized surplus unless it results in profits for all stages involved in the chain (Chopra and Meindl, 2016). As a result of this, a network level approach is emphasized when aiming to increase efficiency and profitability in the supply chain since all facilities impacting costs needs to be considered. Interdependency between actors in a supply chain is significant and managing the relationships between these is of essence to enhance value and reduce costs.

2.1.1 Supply chain management and reverse logistics

Supply chain concepts have traditionally been described as a single downstream flow from supplier and manufacturer to end customer (Dekker et al., 2004; Cohen and Roussel, 2013). Therefore, focus has been directed on the forward logistics in which a firm's outbound distribution is designed to allow the forward movement of goods in an efficient and effective way (Harps, 2003). Since the emphasis previously has been on the forward logistics it has resulted in reverse logistics being perceived as lower priority and, hence, receiving low attention from management (ibid.). The supply chains of today include reverse flows or upstream flows from customers and retailers to manufacturer and supplier. These flows have not been mentioned in traditional supply chain definitions, however, since these processes affects the supply chain it is vital to apply a comprehensive approach in order to optimize the value creation. Thus, as a result of the importance of the reverse logistics the term "closed-loop supply chains" has arised (Lebreton, 2007).

Since reverse logistics being perceived as a significant element of supply chain management, Dekker et al. (2004) claims that it should be analysed in the same way as when a traditional supply chain is investigated. Further, the authors argue that a trade-off is present when firms design their supply chains and a decision must be made whether it should be based on a cost approach or service approach. The correlation between the two approaches can be described as a supply chain that is responsive incurs higher costs. Which direction to lean towards in the trade-off is ultimately decided by the customer who determines if a higher service level is justified (ibid.).

2.2 Return reasons for reverse logistics

Reasons concerning returns through the reverse logistics system have been discussed by several authors (de Brito and Dekker, 2002; Jack et al., 2010; Lambert et al., 2011) who describes reasons related to the senders.

Return reasons related to the sender are divided into *manufacturing returns, distribution returns,* and *customer returns* (de Brito and Dekker, 2002). *Manufacturing returns* relates to the recovered components and products from production. Specifically, such recoveries are defined in terms of surplus of raw materials, components or products that have not passed quality checks and needs to be returned, or production leftovers (Vercraene et al., 2014). Further, *distribution returns* aim to describe the returns that arise during the distribution, such as product recalls, commercial returns among business-to-business firms, stock adjustments, and functional returns (Kleindorfer et al., 2005). The type of return mentioned last is of essence in this thesis since it concerns packaging, carriers, and other types of distribution items. Finally, the reasons for *customer returns* are expressed as business-to-customer commercial returns, warranty returns, service returns, end of use- or life returns (Barky, 2016).

2.2.1 Realizing value in reverse logistics

Toktay et al. (2004) claims that in order to increase the value realized from returned items firms need to manage the quantity and timing of the returns. In practice, this means that managers responsible for the reverse flow of returned items should design the reverse chain with the aim to enhance visibility and increase speed throughout the chain, which ultimately would result in an increase in the value potential being realized (Guide and Van Wassenhove, 2001). In response to how to design a reverse logistics chain Toktay et al. (2004) describe two modelling approaches that can be utilized to study the interdependence between return flow characteristics and system structure. The first approach relates to analysing the value of incentives in terms of return allowance, trade-in offers, and buybacks through creating principle-agent models (Debo et al., 2001). The second approach aim to assess the influence of several relevant factors through a regression analysis (Toktay et al., 2004).

Further, the trade-off between cost and service level, as mentioned in the previous sub chapter, is of significance when considering returned items (Chopra and Meindl, 2016). Return policies are usually a response to the competitive environment firms experience that aims to increase the customer satisfaction levels (Mukhopadhyay and Setaputra, 2011). A consequence of return policies is that they could lead to high costs since they are associated with direct transportation costs and inspection costs. Thus, when studying and examining the return policies it is of essence to evaluate other return policies alternatives (Setaputra, 2005).

2.2.2 Implications related to return flows

Implications arise when goods are returned to its sender due to insufficient quality control of the goods which results in significant uncertainty. To handle these issues, it becomes of essence to establish a dynamic ability of the flow and to adjust to different markets and customers. Thus, developing knowledge and insight on how the various markets works and how the goods are handled in each market is vital (Blumberg, 2005). Also, when addressing these issues, and more specifically managing return flows, relevant information must be used meaning that outdated or irrelevant information does not have a purpose in these contexts. Regarding the handling of information difficulties emerge in terms of the design of the distribution of information across different actors. In order for the return flow of materials to be as effective as possible the different processes need to be coordinated between the actors involved in the return flow. To handle the high uncertainty of the return flow high flexibility in facilities and transport systems becomes evident (Fleischmann, 2001). Thus, the quality of the information available is of significant importance and results in a better decision making process of the transports, staffing, and facilities which ultimately leads to a cost-efficient handling of return flows (Blumberg, 2005). Further, Fleischmann (2001) highlights some differences between return flows and traditional logistic flows. The author argues that uncertainty and variation related to the forecasts impedes on the quality and quantity of materials returned. This is the reason that the uncertainty in the forecasts are perceived as a complex area. Further, due to the large number of actors that are involved in the supply chain network, the return flow becomes more complicated as the risk for a lack of information sharing increases (Fleischmann, 2001).

2.3 Reverse logistics network design

Profits realized by the reverse logistics chain are to a large degree dependent on the network design of the chain. Facilities and other logistics infrastructure needs to be designed in a way that enhances the inbound flow of returned goods if the highest value possible is going to be realized. Thus, the location of the reverse chain’s processes as well as the links between these and the actors, such as transportation and storage, are crucial to understand the reverse logistics chain. Further, the reverse logistics functions have been described as *collecting, testing and sorting, reprocessing,* and *redistribution* (de Brito and Dekker, 2002). Figure 5 aims to illustrate this view of the reverse logistics chain.

The structure, as illustrated by Figure 5, could be perceived as a many to many distribution network, were the inbound part that is associated with the collection and acquisition of the returned goods receives deliveries from multiple locations and the outbound part delivers shipments to several locations (Fleischmann et al., 2003). Further, Fleischmann et al. (2003) argues that although the inbound part has traditionally been perceived as reverse logistics it could obstruct an analysis of the reverse logistics since the inbound and outbound flow are interrelated.

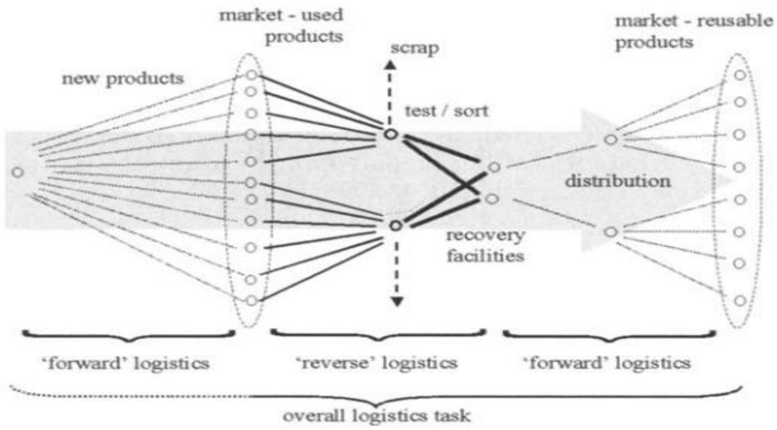

Figure 5: Reverse logistics network structure (Fleischmann et al., 2003).

2.3.1 Return logistics systems

Lützebauer (1993) distinguishes between the three different return logistics systems, which are described below.

Switch pool systems are characterized by each member having their own number of containers which they are responsible for. Due to this, every member of the pool system is in charge of the cleaning, control, maintenance and storage of the containers (Elia and Gnoni., 2015). Pool systems usually include multiple actors, however the two most common types are that the members consists of senders and receivers or by senders, carriers, and receivers of the goods (Kroon and Vrijens., 1994).

In pool systems that consists of senders and receivers both the actors own a number of containers. Containers are transferred between the sender and receiver when the goods are delivered to the receiver’s facilities (Lützebauer, 1993). A carrier is usually responsible for transferring the goods between the two actors and either transport containers filled with goods from sender to receiver or empty containers in the opposite direction to the sender’s facilities.

For the carriers to achieve economic benefits from these transportations and not drive with empty trailers on the way back, the sender in the end need to ensure the carrier that the volume of the number of containers transported to the receiver is the same number of containers that is shipped back from the receiver to the sender (ibid.).

In the second alternative of switch pool systems the carrier also has a number of containers. In this case, when containers containing goods at the sender's facility are loaded onto the carriers truck empty pallets corresponding the number of pallets loaded are provided to the sender (Kroon and Vrijens, 1994). Thus, the sender is not responsible for the managing the return flow of shipped containers. A pallet exchange like the one described is the norm in this type of switch pool systems.

In *systems with return logistics* all the containers belong to a central agency which is responsible for the containers also after they have been emptied by the recipient (Lutzebauer, 1993). Thus, the central agency is responsible for transferring all containers between different actors, however, the agency require that the empty containers are bundled and stored by the receiver until a sufficient number of containers has been accumulated which enables a cost efficient collection by the agency (Elia and Gnoni, 2015). Lützenbauer (1993) distinguishes between the following two systems:

- Transfer system. This system is characterized by the sender constantly utilizes the same type of containers since the transfer system only manage the return flow of empty containers from receiver to sender. Instead the tracking and tracing of containers, cleaning, maintenance, and storage are under the sender's responsibility. Further, the sender also manages the flow of containers ensuring a sufficient number (Lützebauer, 1993).
- Depot system. The overall idea of this system is that containers are stored at predetermined depots. The depot provides the sender with the required number of containers and when the containers have been transported to the receiver empty containers are transported back to the depot and stored until needed again by the sender. During the time of storage, the containers are maintained if required. This system can further be divided into two sub groups (Cobb, 2016).
    - The *book system* is characterized by the central agency conducting a thorough review of the flow of containers. When the agency delivers a certain number of containers to the sender the corresponding amount of the containers are then debited in the sender's account by the agency. On the other hand, when the sender ships containers to a receiver the sender's account is credited for the number of containers shipped, while the receiver's account is debited (Roy et al., 2016). Thus, the agency requires the sender to provide complete information on shipments, place of receiver, and the number of containers involved in the shipment. This information combined enables the agency to monitor the flow of containers (Yang et al., 2016).
    - In the *deposit system,* the sender is required to pay for every container that is utilized and the deposit reflects at least the value of the containers (Lutzebauer, 1993). When the sender sends a shipment to the receiver the containers are debited to the receiver who in turn debits them to their customers. At the end of the chain, when the goods have arrived at the end customers, the containers are collected by the agency which in turn pays the value of the collected pallets

to the actor they are collected from (Roy et al., 2016). The deposit in a system like the one described should be sufficient to cover loss, theft, and damages to the containers which in turn results in a monitoring track and trace system to manage the flow of containers is not required. Further, since the deposit system includes cash flows between different actors it enables a fast return rate of the containers as a result of the actors need to get their money back (Kroon and Vrijens, 1994).

In *systems without return logistics* the containers in the system are also under the central agency's ownership. When the sender requires containers, they are rented from the agency and returned back when they are not needed. The system is characterized by the sender having the full responsibility of the containers when it comes to controlling, cleaning, maintenance, and storage as well as return logistics (Elia and Gnoni, 2015). An advantage with systems without return logistics is that it possesses a potential for the sender to reduce its costs by renting containers instead of purchasing them (Roy et al., 2016).

The type of return system a sender chooses to use is dependent on the goods involved. For instance, the type, weight, structure, and quantity of the goods affects the selection of return system. However, other factors do also affect this decision. The scope of the return system (international, regional, national), coordination between actors, willingness to invest, available storage space, control possibilities, size of the organization as well as the acceptance in the market are all factors that have an impact on the selection of return systems. Further, Table 1 summarizes the different logistics return systems that have been described (Kroon and Vrijens, 1994).

Table 1: A summary of the different logistics return systems, adapted by (Kroon and Vrijens, 1994).

Systems	Essence	Partners	Responsibility	Possibilities
Switch pool	Every partner has an allotment	Sender, recipient	Every partner is responsible for his own allotment	Direct switch
		Sender, carrier and recipient		Exchange-per-exchange switch
With return logistics	Return logistics by agency	Agency, sender, carrier, recipient	Agency	Transfer system
				Depot system with booking
				Depot system with deposit
Without return logistics	Rental of the containers	Agency, sender	Sender, also for the return logistics	Rental of the containers

2.3.2 Design a pallet management system

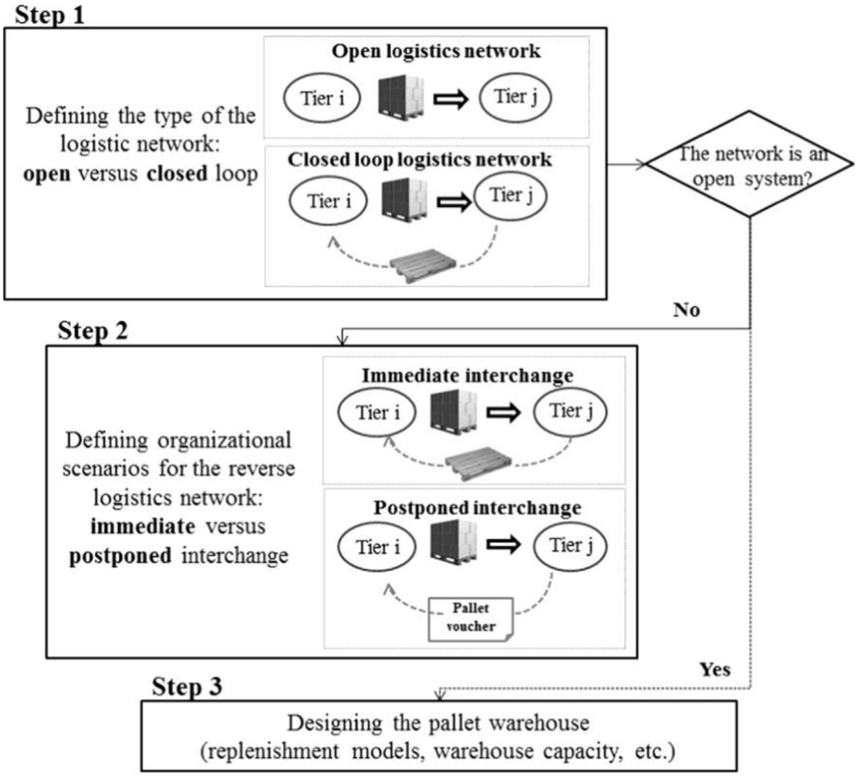

Figure 6: The decision making process in pallet logistics design (Elia and Gnoni, 2015).

Elia and Gnoni (2015) presents a decision-making framework concerning the design of a pallet logistics process which is divided into three steps, as illustrated by Figure 6. The first step relates to defining the structure of the logistics network regarding pallets. Two different models are used to describe pallet logistics processes (ibid.). An *open network* is characterized by an upstream firm sending goods loaded in pallets to a downstream firm, which in turn do not return the empty pallets to the upstream firm. Instead, the downstream firm credits the upstream firm, not only for the goods, but also for the pallets carrying the goods (Hariga et al., 2016). On the other hand, if a *closed loop network* is in place, the pallet logistic process is characterized by the need to manage empty pallets between downstream and upstream firms in a reverse flow (Roy et al., 2016).

Both the open network and the closed loop network has their benefits. For instance, closed loop networks are more complex and requires larger resources to manage the reverse flow of empty pallets from customers. This affects the inventory and logistics activities for the companies involved since it results in the decision initiating the reverse flow is made by the downstream firm. Thus, the inventory levels at the upstream firm is volatile to the reverse flow of the empty pallets from the downstream firm since these return deliveries are not notified in advance (Glock, 2017). However, the costs associated with the replenishment of the pallet logistics process can be reduced with the closed loop network and managing the inventory of the empty pallets becomes easier. This is achieved since the empty pallets related to the closed loop network is utilized several times in the system (Elia and Gnoni, 2015).

Has an open network been selected in the first step of Figure 6, the next step is to set up the management system of the inventory and design the empty pallet storage warehouse, in terms of replenishment models and warehouse capacity (Elia and Gnoni, 2015).

If, however, the pallet logistics process is designed based on the closed loop network the logistics introduced with the reverse flows represent another element of the design problem, as referred by the second step in Figure 6. An essential cornerstone when aiming to design a closed loop network is to consider the role of the logistics service provider. This is relevant since both the forward and reverse flows needs to be organized and handled. The flows that the logistic service provider usually handles are depicted in Figure 7 (ibid.).

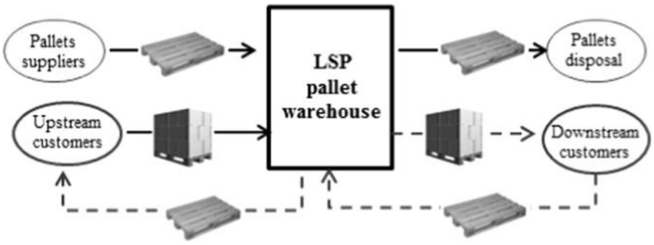

Figure 7: The closed loop pallet management system according to a LSP point of view (Elia and Gnoni, 2015).

Regarding the definition of the organizational scenarios for the reverse logistics network, as illustrated by the second step in Figure 6, there are two different systems concerning the interchange of empty pallets; direct and postponed systems. Both these systems and their respective activities are illustrated in Figure 8 (ibid.).

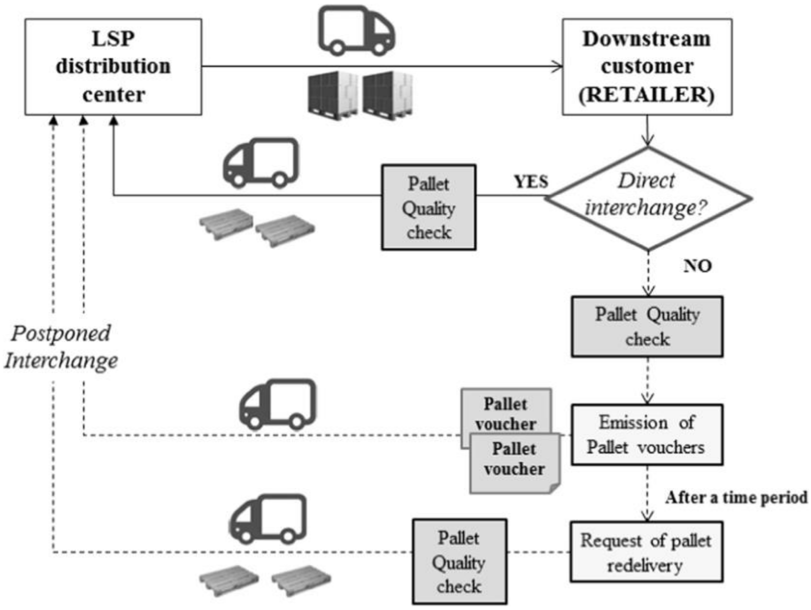

Figure 8: Direct and postponed pallet interchange schemes (Elia and Gnoni, 2015).

A direct interchange system is characterized by the logistics service provider making a delivery to a downstream firm, while at the same time arranging for the reverse flow of empty pallets that are collected from the same firm (Hariga et al., 2016). Systems like this relates to that the same number of palletized loadings delivered to the downstream firm needs to be delivered back to the logistics service provider. The described synchronization between forward deliveries and reverse flow of empty pallets requires the courier delivering goods to a downstream firm to wait a considerable time, resulting in non value added activity, while the goods are unloaded and the empty pallets are loaded onto the truck. However, there is no established standard that is recognized as common, instead different standards for pallets applies universally. The standardization in this sense refers to agreed size and materials of pallets. Regardless of this, the courier should still be able to accept pallets corresponding to the standard of the area of business (Li, 2006). Thus, the courier should accept standardized empty pallets at the premise of the downstream firm, instead of waiting for its own pallets to be unloaded from goods and loaded onto the truck. Consequently, waiting times at the downstream firm will be reduced for the courier, which will only have to check whether the standard corresponds to that of those pallets delivered (Elia and Gnoni, 2015). If the downstream firm is not able to provide empty pallets whose standards does not corresponds to the pallets delivered by the logistics service provider, the downstream firm becomes responsible to compensate the courier for the number of empty pallets that have not been delivered back (Roy et al., 2016).

The postponed interchange is characterized by the courier not waiting for empty pallets to be loaded to the truck at the time of delivery. Instead, after the downstream firm has inspected the pallets delivered for any defects, it initiates a pallet voucher (Elia and Gnoni, 2015). Here, the empty pallets offered to the pallet voucher also needs to be quality inspected in order to assess the number of pallets corresponding to the agreed rules on accepted pallets (Glock, 2017). However, empty pallets do not need to be offered urgently to the pallet voucher, since it is possible for the downstream firm to postpone the delivery of empty pallets and not issue a pallet voucher immediately (Hariga et al., 2016). According to the European interchange system this postponement of empty pallets has been limited to three months (ECR, 2006). Thus, the number of pallets corresponding to the number of delivered pallets, whose quality has been verified, should be offered to the pallet voucher before the stated time limit. Further, if the downstream firm does not offer the empty pallets in time, they will be forced to compensate the logistics service provider for the cost corresponding to the value of the empty pallets. When the logistics service provider receives the delivery of empty pallets, a quality inspection needs to be performed since the quality needs to be verified in order for a comparison to be made with the numbers of pallets that the voucher has stated as accepted (Elia and Gnoni, 2015).

Finally, both the postponed and the direct interchange systems possess strengths and weaknesses. Analysing the postponed interchange system from a logistics service providers view, it can be concluded that waiting times at the downstream will be avoided (Roy et al., 2016). However, the weakness of such a system relates to the delay time, resulting in no direct availability of empty pallets to the logistics service provider. If instead a direct interchange system is in place, the inventory management will be facilitated. Further, due to the lack of reverse flow of empty pallets the level of replenishment will increase (ibid.).

2.4 Quality control

Bergman & Klefsjö (2012) define quality as a products’ ability to satisfy, or preferably exceed, the needs and expectations of the customers. The authors further claim that customers can be divided into external and internal ones, where the latter are represented by the staff within a firm. To satisfy both these customers’ needs the focal firm needs to be able to perform its processes with a high and even quality level. Moreover, when managing the quality of the current process it is essential to analyse and prevent any variation from the quality levels that has been established (Grigori et al., 2001). A method commonly used to analyse the quality of a firm's processes is through visual inspection (Marie et al., 2016).

2.4.1 Visual inspection

The essence of visual inspection on incoming deliveries is emphasized by several scholars within the quality control as well as total quality management areas (Klefsjö and Bergman, 2012; Marie et al., 2016; Peris-Ortiz et al., 2015). Sablatnig (1997) defines visual inspection as a process that determines whether a product differs from the given specifications. There are multiple existing methods that comprise the concept of visual inspection, for instance automated machines, machines that require an operator, and human inspections. The latter one is the most common method used and Marie et al. (2016) claims it to be the best method for detecting deteriorated products. Although visual inspections being performed by humans are reported to be effective there are still limitations as well as complications to this method (Klefsjö and Bergman, 2012; Shilling, 1982; Liker, 2009). For instance, Table 2 provides references to some studies concerning the complication that arises from the result of visual inspections performed by humans. Accordingly, Hendricks and Singhal (2001) states that investing in relevant tools and systems can reduce the errors from visual inspections, but it cannot completely eliminate the errors. Further, literature on different types of visual inspections reports error rates of 20-30 percent (Hendricks and Singhal, 2001; Marie et al., 2016; Klefsjö and Bergman, 2012). In order to manage the high error rates, firms are directing their focus towards the opportunity to train controllers that performs the inspections rather than allocating this activity to manufacturing workers. Moreover, studies show that training employees to detect deferring products results in a lower error rates while improves the operator's decision making ability (Wiener, 1975; Marie et al., 2016).

Table 2: Factors that affect the outcome of visual inspections. Adapted from Marie et al., 2016.

Visual acquity	McCormick (1950), Courtney (1985)
Eye movement	Findlay (1997), Näsänen et al. (2001)
Age	Ball et al. (1988), Cerella (1985)
Tiredness	Jebaraj et al. (1999a), Lin et al. (2009)
Concentration	(Sagi, 2010)
Training/Feedback	Chabukswar et al. (2003), Wang et al. (1997), Rebsamen et al. (2010)
Memory	Shore and Klein (2001), Maxwell et al. (2003)
Motivation	Rousseau (1977), Hays and Hill (2001)

Further, the outcome of visual inspections is affected by the repeatability and reproducibility of the performed inspection (Marie et al., 2016). Repeatability is the difference in measurement that results from measuring the same feature on a specific part, while reproducibility is the average variation in measurement caused by workers when measuring the same feature on a specific part (Klefsjö and Bergman, 2012). These terms are interdependent on the worker's capacity to detect defected products and to evaluate these defects. Marie et al. (2016) claims the repeatability and reproducibility to be closely related to the exploration and evaluation of defects. Despite visual inspection has been subject to several studies, still the exploration of studies or the detection of defects are perceived as the major part of the concept of visual inspections. Factors that affects the number of detected defects has been argued and visual acuity, lighting, inspection time, and feedback are aspects reported to have an impact of the detection of defects (Courtney, 1985; Näsänen et al., 2001; Ball et al., 1988; Megaw, 1979; Lin et al., 2009; Sagi, 2010; Chabukswar et al., 2003; Hays and Hill, 2001).

Marie et al. (2016) claims that defects are often known and that the workers performing the visual inspections have knowledge of the defects they are supposed to detect. Further, the authors mention that the controllers can have easy access to pictures illustrating the defects. The overall objective of performed visual inspections is to detect any defects and at the same time fulfill the expectations imposed by customers. This could be achieved by not only detecting any defects but to also identify any irregularities that can be perceived as a defect by customers. Given the difference between extensive and limited inspection controls, some customers might detect defects that has not been detected by other customers (ibid.).

2.5 Supply chain coordination

Traditional supply chains as well as supply chains that considers the reverse flow are characterized by multiple interactions and extensive involvement by decision makers within and across firms regarding the efficiency and profitability of the supply chain (Debo et al., 2001). Despite extensive interactions across firms within the supply chain, decision makers might still pursue their own local objective without considering the overall profitability of the supply chain. Thus, some level of coordination between firms within a supply chain is of vital importance in order to align all decision makers with the same objective of creating highest possible overall efficiency of the supply chain. According to Debo et al. (2001), supply chain coordination can be achieved by focusing on *incentive alignment*, *information sharing*, and *functional integration*.

Multiple firms are usually included in a supply chain, where each firm has its own objectives. In order for the supply chain to achieve high levels of customer service and become cost effective it is necessary for all the members of the chain to work toward the same goal. Thus, overall profitability of the supply chain can be maximized if the goals and incentives of the members in the chain are aligned. This means that risks and rewards as well as costs of conducting business are fairly shared between the different actors in the supply chain (Narayanan and Raman, 2004). However, in case the incentives are not aligned the overall profitability of the chain will not be optimized, resulting in excess inventory, stock outs, incorrect forecasts, inadequate sale efforts, and poor customer service.

Narayanan and Raman (2004) claims that there are three reasons why issues related to incentives appears in the supply chain. The first reason concerns firms' lack of insight and knowledge related to other firm's activities, making it difficult to ensure these firms activities are in line with those of the supply network. Further, the authors emphasize that actions that cannot be observed are present all along the supply chain. Moreover, aligning objectives when firms in the supply chain have access to different information and knowledge is another reason to incentive obstacles appear in the chain. This is illustrated in situations where suppliers do not want to share their cost data with the manufacturer in fear of the data being used by the manufacturer against the suppliers to reduce their profit margins (Debo et al., 2001). Consequently, the suppliers will be unwilling to share data and involve in activities with the manufacturer if it implies that the supplier's data would be gathered. As long as the conditions for sharing information between supplier and manufacturer are not fair the supply chain will not be as efficient as possible. The third reason, as described by Narayanan and

Raman (2004), relates to that incentive schemes often are not designed properly. Chopra and Meindl (2016) illustrate this by describing badly designed sales force incentives as a major limitation to achieve coordination in the supply chain. A manufacturer usually measures sales as the amount of sold products to the distributors (sell-in) instead of the amount sold to the end customer (sell-through) which represents the real demand. Measuring the sell-in instead of the sell-through is characterized by the manufacturers sales force not managing the sell-through. Sales force incentives that are structured based on sell-in instead of sell-through give rise to higher fluctuations of placed orders than the actual variability of customer demand (Chopra and Meindl, 2016).

Three measures can be taken to achieve supply chain coordination; *rewrite contracts, reveal hidden information, or develop trust* (Narayanan and Raman, 2004). By rewriting contracts with members of the supply chain that are based on the actual outcome of the chain instead of outcomes between single stages lead to aligned incentives. Rewriting contracts is essential when sales force incentives are improperly structured. For instance, contracts based on sell-through instead of sell-ins would stop sales staff from pushing products and stimulate forward buying resulting in reduced order variability (Chopra and Meindl, 2016). Incentives within a supply chain can also be aligned by reveal hidden information through sharing information across the chain. If a member in the supply chain share information of the actual demand with the rest of the chain, it becomes possible for the other members to forecast future demand based on the actual customer demand. With all stages sharing information it leads to less information being distorted since the available information creates opportunities for each member of the supply chain to respond to the same information. Further, by developing trust within the supply chain incentive obstacles can be reduced. Trust is a precondition for facilitating the process of achieving coordination between the stages across the supply chain. For instance, an upstream actor in the supply chain does not need to allocate resources to establish and maintain forecasts if it trusts the information received from an actor downstream. Also, an actor can reduce its inspection quality control if it trusts the quality and quantity delivered by its supplier.

3. METHODOLOGY

The following chapter describes the methods used for this thesis. A presentation of the research design is followed by a description regarding how the data was gathered. Further, the literature review and the interview sample is presented. The reliability and validity of the study is described before the section concludes with a presentation of the methods used for analysis.

3.1 Research design

A case study approach on SCA Edet mill was used to conduct this thesis and the topic used in the study is pallet logistics. According to Bell (2010) the benefits of a case study is presented in its ability to provide individual researchers an opportunity to study a specific area in detail during a limited time period. Further, in order to achieve a good understanding of the studied area it is essential to gather information from different sources (Patel and Davidson, 2003).

3.1.1 Hermeneutic approach

Various approaches and methods of analysis can be used to make interpretations and gain knowledge of the studied event. A hermeneutic research approach is based on this concept and aims to study the meaning of thinking, actions, experiences, culture, and texts by subjectively assessing and interpreting the researched phenomena. According to (Patel and Davidson, 2003) the ultimate goal of a hermeneutic research design is to examine and understand individuals subjectively experienced world, by collecting information through the use of a qualitative approach and non-directive interview techniques. Further, the distance between the subject who conducts the study and the object of study is not clear since gaining understanding of experiences cannot be accessed through a true/false analysis (Hunter, 2004). Instead, the researcher adopts a comprehensive approach in which broad knowledge of the field of study is obtained. According to Wallen (1996) four principles defines a hermeneutic research approach. The first principle concerns interpreting the meaning of thinking, actions, experiences, culture, and texts. Secondly, the researcher should have some knowledge relating to linguistics and culture before performing the study. The third principle relates to the fact that the researchers often switch between interpreting the field of study based on a comprehensive view and a more specific view. Finally, Wallen (1996) emphasizes the essence of conducting an interpretation based on a context.

Adopting a hermeneutic research approach is necessary in answering the first research question. When answering if standards and routines are being complied with regarding received deliveries of empty pallets, it is necessary to study the thinking and actions of the concerned staff, which is why a hermeneutic approach were deemed relevant. Further, interviews with staff responsible for this inspection quality control will be held since their professional experience in that area will be of significance later when presenting solutions aiming at improving the current situation.

3.1.2 Abductive approach

Abductive research methodology aims to address the weaknesses of associated with deductive and inductive approaches and is thus perceived as a combination of these two approaches. Deduction approach takes its starting point in established theories and concepts to lead to observations and later on a confirmation of the original theory. Thus, utilizing this approach has a strong impact on the type of information to be collected. Since theories and concepts are highly valued in deductive approaches it reduces the scientist's potential to include own thoughts which constrains the possibility to realize new findings (Trochim, 2006).

An inductive approach differs considerably from deductive approaches and are often perceived as the opposite to deductive approaches (Trochim, 2006; Patel and Davidson, 2003; Kvale, 1996). This type of research approach takes its starting point in specific observations and ends in generalizations and new theories. As understood, inductive approaches are more exploratory in nature leading to addressing certain issues without a base of established theories and concepts. In contrary to the deductive approach, inductive research is characterized by that the scientist's own thoughts are significant in the creation of new theories (Trochim, 2006).

The research approaches mentioned in this section have often been described as opposites to each other in research approach literature. However, since deductive and inductive approaches are the inverse of each other they can be combined into a process that continuously shifts from theories to observations and back to theories again. A process, that combines deductive and inductive approaches, is defined as an abductive approach (Thagard and Shelley, 1997).

Since this thesis combines both established theories within reverse- and inbound logistics and aims to realize new opportunities within these areas, the abductive approach becomes useful to apply. Thus, the abductive research of this thesis can be described as utilized theories of reverse and inbound logistics, which corresponds to the deductive approach, as well as collected data and information based on the author's ideas and thoughts, which relates to the inductive approach.

3.2 Data collection methods

The data collection methods used will be discussed in this thesis. A mixed methods approach was used, implying that both qualitative and quantitative methods were utilized when collecting data.

3.2.1 Qualitative data collection

Collecting data using a qualitative approach is essential when studying the underlying processes and causes of a specific field of study or behind stated results. Thus, a qualitative data collection provides information more complex than the objective and accurate information retrieved from standardized methods (Patton, 2005). Further, Eklund (2013) claims that qualitative data collection should be characterized by researchers aiming at using triangulation to achieve a higher credibility of the study. The objective with using triangulation is to collect data from several sources in order to verify the accuracy of the data (Trochim, 2006). Specifically, this can be translated to interviewing multiple people from various positions and responsibilities, which is why forklift drivers, team leaders, transport planners, warehouse managers, and factory logistics managers have been chosen.

The operators handling the empty pallets, which is the forklift drivers, were interviewed with the objective to gain an understanding of the everyday operations and to get an insight of their thought regarding the current inspection quality process of received deliveries of empty pallets. Team leaders, transport planners and warehouse managers were chosen to gain knowledge of established standards and routines regarding the empty pallet process as well as to gather information regarding the administrative part of the process. Finally, it was considered important to give the factory logistics manager the opportunity to express thoughts and ideas of the vision regarding the empty pallet process.

Relating the quantitative data collection to the research questions, it can be stated that the quantitative method was found useful in answering all three research questions. However, the main goal with the qualitative data collection was to address the first research question, in which this method had a major contribution to the presented results. Further, by giving multiple employees the opportunity to express their thoughts the collected data could easily be verified which ultimately contributed to securing the accuracy of the collected data.

3.2.2 Quantitative data collection

The objective with quantitative data collection is to make use of information expressed in numbers to measure or assess a certain field of study (Eklund, 2013). Collecting data with this method is characterized by the use of structured and standardized methods, making it easy for others interested in the field of study to achieve the same results (Björklund and Paulsson, 2012). Information gained from a quantitative data collection presents rather objective and considerably accurate results compared to the qualitative data collection. In order verify the collected data, researchers that adopts a quantitative approach uses internal validity which represents the level of which obstacles to internal validity have been considered (Trochim, 2006). The major obstacles to internal validity relates to the history of data, in which the data collected should be relevant in time, and selection of data, meaning that the data collected should represent the actual field of study (Eklund, 2006).

A majority of the quantitative data utilized in this thesis were collected from SAP, which is the ERP system the firm uses, and from Microsoft Excel files. The latter source of information constituted a variety of reports regarding the number of empty pallets delivered, the stock of empty pallets, number of empty pallets per delivery, number of empty pallets per truck, etc. Also, a business intelligence software tool was used to access data regarding volumes relating to certain countries. The countries were restricted to Norway and Denmark and the data collected represented figures from the previous year (2016) until the present year (2017). Further, data were collected from different pallet pooling systems in order to understand the various conditions of each pooling system.

3.2.3 Literature review

The majority of the literature review was accessed through Chalmers library databases and Google Scholar. Additional information could be gathered from lectures of professors at the SCM programme at Chalmers and from the intranet of SCA. The references used in this thesis are mainly based on scientific journals and edited books from different publishers, as illustrated in Table 3. Further, the various search terms used to find journals and books can also be found in the table.

Table 3: A summary of the literature used.

Search terms	"pallet logistics”; "reverse logistics"; "closed-loop supply chains"; "reverse supply chains"; “inbound logistics"; "inspection quality control"; "pallet management strategies"; "returnable containers"; “product return management”; “reprocessing operations"	
Scientific journals	Journal of Operations Management	(Elsevier)
	Supply Chain Management: An International Journal	(Emerald)
	International Journal of Physical Distribution and Logistics Management	(Emerald)
	Manufacturing and Service Operations Management	(Informs)
	Production and Operations Management	(Wiley)
	International Journal of Management Reviews	(Wiley)
Edited books	Reverse Logistics - Quantitative Models for Closed-Loop Supply Chains	(Springer)
	Supply Chain Management and Reverse Logistics	(Springer)
	Supply Chain Management	(Pearson)

3.3 Interview structure

In this study interviews are one of the primary sources of data, where the respondents have been provided with the opportunity to express their thoughts and concerns related to the pallet logistics at the SCA Edet mill. Since this study is based on the theories of a case study, gathering relevant data and gaining a complete understanding of the studied area is essential. In order to achieve this a selection of interviewees must be made carefully, in which the interviewer should rely on multiple information sources that could complement the issues expressed by the respondents (Bohlin, 2015). Interviews associated with a qualitative research approach are less structured if compared with those related to quantitative research methods. Thus, unstructured and semi-structured interviews are used frequently in qualitative studies since the focus of is based on the respondent’s experience. On the other hand, structured interviews are the general method in quantitative study areas, where the interviewer’s questions are the focus of the interview. Specifically, this means that the possibility is present to let the respondent decide which direction to take during the interview. This is not the case in quantitative research approaches since a predetermined questionnaire controls the interview (Kvale, 1996).

Given that a mixed method approach was utilized in this study both qualitative and quantitative based interviews were considered as appropriate. At the beginning, unstructured and semi-structured interviews were mainly performed in order to gain knowledge of the studied area. Thus, no established theory was used as a basis for the interviews, instead the questions were open and focused more on the respondents. As the interviewer gained a broader understanding, the interviews became more structured to extract quantitative data. In this case, interview questions were designed based on the information obtained from the qualitative interviews, observations, internal documents as well as theory related to the subject. Further, questions were adjusted between the interviews depending on the responsibilities of the respondents.

3.3.1 Sample of interviews

Table 4 summarizes the interviewees that contributed to this study. Several interviews with respondents were based on different data collection methods. However, it should be noted that no combined approach was used in single interviews. Instead, different approaches were used in separate interviews with the respondents.

Table 4: A summary of interviewees contributing to this study and the data collection methods used in interviews.

Interview Category	Designation of Interviewee	Data Collection Method
Key stakeholders	Forklift drivers	Qualitative
	Team leaders	Qualitative
	Transport planners	Qualitative/Quantitative
	Warehouse manager	Qualitative
	Controller	Qualitative/Quantitative
	Transport manager	Qualitative/Quantitative
	Raw materials controller	Qualitative
	Logistics manager	Qualitative/Quantitative
External	Customer service manager	Qualitative
	Logistic service providers	Qualitative/Quantitative

Forklift drivers were interviewed based on their active role in the process regarding empty pallets. These employees handle the operative part of the process where they inspect, sort and decide whether to dispose or refurbish the pallets. Consequently, their experience when it comes to the physical handling and inspection process of the empty pallets is highly valued in order to understand the problematics regarding this process. Team leaders were also selected to be part of the interview process as a result of questions related to the staffing and time allocated to the handling of empty pallets. Conducted interviews with the forklift drivers were usually performed in the empty pallet warehouse but also in conference rooms in the office building. Interviews performed in the warehouse were usually short and of a descriptive nature where the forklift drivers described their tasks and activities as well as answered simple questions. On the other hand, interviews performed in the office were deeper where the respondent expressed concerns over the current process and where questions related to the inspection control process where emphasized.

Also, team leaders were interviewed in the office building. Interviews were performed in the office building due to the calmer environment which would help the respondents to easier focus on the questions. Further, transport planners are also represented in the sampling due to their role in the administrative part of the empty pallet process. Transport planners dispatches empty pallets from LSPs, handles the inbound delivery from customer returns, as well as decides the number of pallets needed to be delivered to the mill. Thus, questions related to these topics where discussed with the transport planners. The warehouse manager's perception of the process and expertise regarding replenishment models, warehouse capacity and inventory levels formed the focus of this interview. Also, the factory logistics manager was included in the sample of interviews, in which the performed interviews were more of a descriptive nature. Thoughts regarding a potential future state of this process and previous as well as current improvement work were expressed during these interviews.

Interviews were also conducted with external partners, where a discussion with the customer service manager at SCA's office in Gothenburg was held. Here, the topic related to agreements with pallet pooling systems. Further, LSPs were included in the interviews in order to gain an understanding of the pallet logistics from their point of view.

3.4 Reliability

Reliability relates to the quality of a study and is perceived as a measure on how repeatable or consistence a performed measurement is (Trochim, 2006). Thus, the field of study is thought to be reliable if the result of the study is not affected by random variables that have a negative impact on the expected result (Eklund, 2013). More specific, this means that if the study is performed during similar conditions an identical outcome should be expected. Random variables affecting the result of the study can be divided into human factors and environmental factors (Trochim, 2006). The human factors relate to the person's mood, if they are tired or fell ill. While the environmental factors relate to the light, noise and other environmental factors that could have an impact on the outcome. Further, Ejvegård (2003) claims that the outcome of a study does not have any value if it is not reliable.

Relating the qualitative data collection to the concept of reliability it can be stated that noise could be perceived as a valid concern to the reliability of this study. Handling empty pallets in the warehouse exposes the employees to loud noises from other forklifts, the sorting machine and other warehouse related activities. However, these environmental factors are not continuously present. For instance, the sorting machine give rise to loud noises only when it is operating. Still, it may be difficult to understand the forklift driver's expressions. Due to this, interviews with forklift drivers where held in a more peaceful environment. These interviews were then combined with observations of the activities when handling the empty pallets. By first listening to the forklift drivers and then observe them increases the reliability of this thesis since the observations provide some kind of assurance to how much of data collected during the interviews corresponds to the actual situation.

Regarding the quantitative data collection reliability could be ensured through repeated measurements which provides an overview to how much the different measurements differ from each other. Also, by double checking calculated figures and receiving response from employees further increased the reliability. Specifically, this can be related to the calculation on the number of empty pallets, storage space required and calculations of the sorting machines capacity were double checked by observations and measurements in the warehouse and through the feedback from employees directly involved with these tasks.

3.5 Validity of data

Validity refers to how well the researcher has been able to study the intended problem and relates to the validity of the measurement (Ejvegård, 2003). In order to achieve a high validity, it is essential to ensure the observation of the actual problem and not the observation of an adjacent problem (Eklund, 2013). Thus, validity is a measurement of the ability to study, analyse and interpret the intended and relevant objects of the study. Obstacles affecting the validity is described as systematic errors and is perceived as bias in a performed measurement (Trochim, 2006).

There were two activities that helped ensure the validity of this thesis. Firstly, the initial interviews that were held with concerned staff guided the researcher to study and observe the actual problem. For instance, as presented in subchapter 4.1, forklift drivers expressed concerns for the sorting machine, which is one step in the inspection process of empty pallets, claiming that it was not accurate. This guided the researcher to study the accuracy of the sorting machine in order to fully understand the problematics with the empty pallets. Secondly, to handle the systematic errors as described by Trochim (2006) several calculations were performed to calculate the same object. For instance, when calculating the capacity of the sorting machine the time were measured for each pallet to be processed through the machine. This was then compared to the calculations of the demand and inbound delivery of empty pallets resulting in a capacity that corresponded to the previous approach. Since these two methods does not have the same systematic errors it was possible to receive feedback of whether the collected data is representative to the actual problem and the intended study.

3.6 Methods for data analysis

Methods used for analysing the collected data are based on both quantitative and qualitative methods. The methods used for the research question will not be identical. For instance, the first research question is analysed with a different method than the second and third research question.

3.6.1 Regression analysis

A regression analysis is a statistical method that aims to evaluate the impact between two or more variables. When performing a regression analysis, the variables are divided into *dependent* and *independent* variables, see Figure 9. Factors that are of interest for the study or essential for the understanding of the study are termed as dependent variables. On the other hand, independent variables are related to factors that are thought to have an impact on the dependent variable (Gallo, 2015).

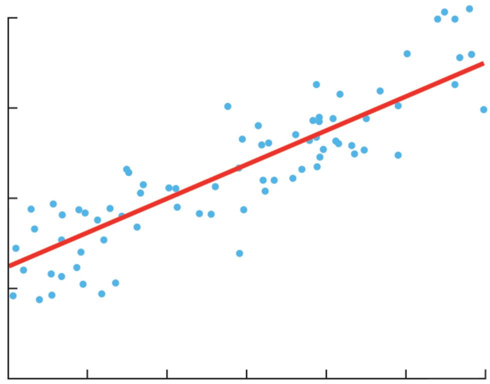

Figure 9: Illustration of a regression analysis, where the line emphasizes the relationship between two variables (Gallo, 2015)

Further, regression analysis can be of two different types; *single* and *multiple*. Single regression analysis refers to the use of two variables as previously mentioned. When instead conducting a multiple regression analysis one or several control variables (regressors) are used. Regressors are defined as variables that are thought to impact the actual relationship and should therefore be eliminated from the analysis (Watson, 2007).

A regression analysis is performed in order to investigate if a correlation exist between the different errors when pallets are stored outside without any protection from the weather. Simultaneosly, the hypotheses states that "*is there a relationship between weather and* *errors"*, in which 12 different regression analyses have been performed – one for each error. The independent variables relate to the temperature during the sampling of the pallets. During the months of February and Mars, empty pallets that had been stored outside were inspected and for each inspection the temperature was noted. Dependent variables in the conducted regression analysis relates to the number of pallets with errors. The first inspection of pallets comprised 288 pallets in which the appearance of the different errors in this inspection were noted. The complete time series can be found in Appendix A.

Regression analysis has been used as a method for analysis related to the first research question and aims to reflect the impact of standards and routines not being complied.

3.6.2 Decision making process in pallet logistics

The framework illustrated in Figure 6 as presented by Elia and Gnoni (2015) will in this study be used as a method for analysis. Steps 1 and 2 of the figure will be used to analyse the third research question where the outcome will establish the design of the different flows to Norway and Denmark. The last step of the figure will be used to answer the second research question where the current design of the pallet warehouse will be reviewed. Here, the outcome will focus on the warehouse capacity and inventory levels.

4. EMPIRICAL FINDINGS

This section presents the empirical findings from the collected data. It starts with describing the pallet demand at the SCA Edet mill and continuous with the ordering process of pallets. The pallet handling is then described and followed with a presentation of the current storage and warehouse capacity. Finally, the section is concluded with a description of SCA's export pallet process.

4.1 Pallet demand at SCA Edet mill

A declining trend in the number of ordered pallets has been present during the majority of previous year, see Figure 10. Such a large variation in the ordered quantity of pallets is rare at SCA Edet mill and is not indicated by a decrease in customer demand. Instead, it can be related to an initiated project which included exchanging a producing machine with a more effective machine. Thus, the disassembly of the machine resulted in a reduced capacity at the mill leading to less pallets needed. The increase in ordered number of pallets, starting from week 40, relates to when the new machine was assembled and started producing. However, the machine will not reach its fullest capacity during the first periods of use since all the settings need to be adjusted gradually.

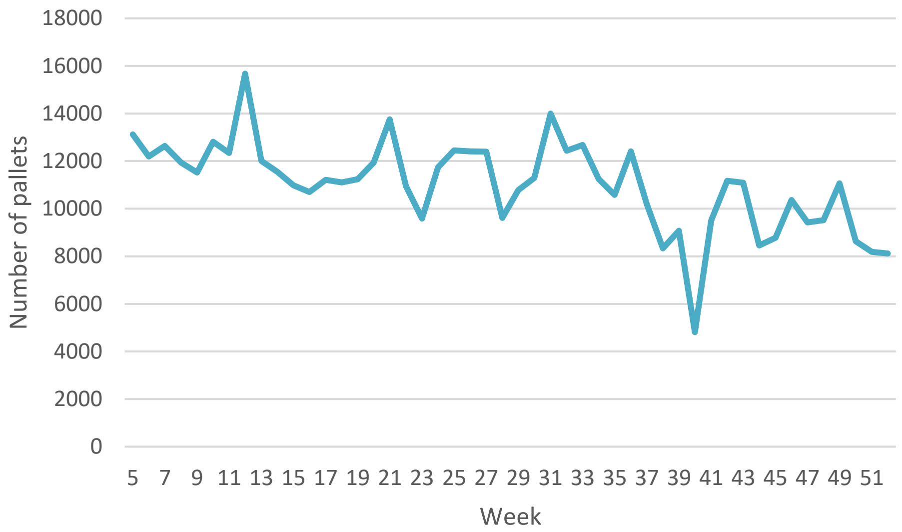

Figure 10: Ordered number of pallets per week, during 2016.

A comparison between the number of ordered pallets and consumed pallets is illustrated in Figure 11. It should be noted that consumed pallets between week 28 and 33 is not associated with a sudden drop and increase in demand. Rather this deviation is explained as the lack of documentation of the consumption during these weeks. Nevertheless, the figure clearly indicates the difference between ordered and consumed pallets, in which the number of ordered pallets does not follow the graph of consumption. Further, the two graphs contradict each other at times when the consumption decreases while the ordered pallets increases. Specifically, the graphs can be related to both overflow as well as lack of pallets at the SCA Edet mill.

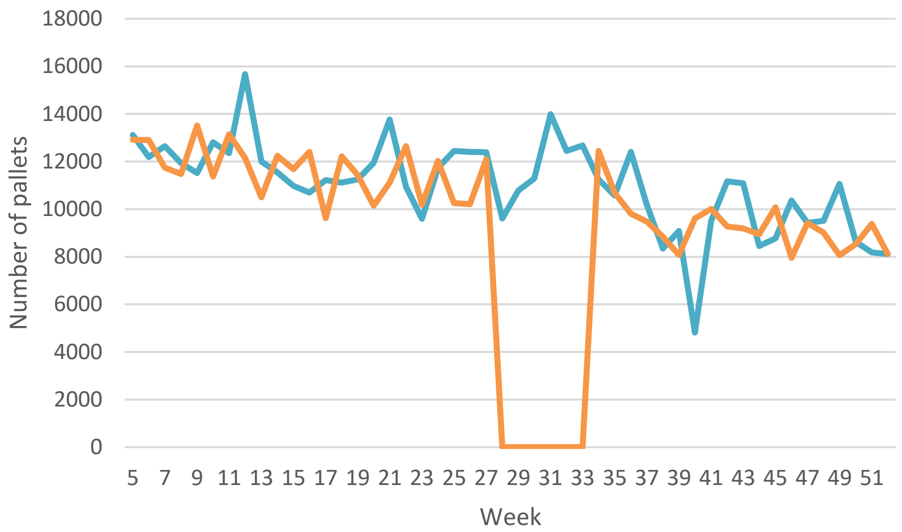

Figure 11: A comparison between ordered and consumed pallets, during 2016. The blue line represents ordered pallets, while the orange line represents consumed pallets.

4.2 Ordering of pallets

Transport planners at the SCA Edet mill are responsible for ensuring the availability of pallets. The deadline for ordering pallets from suppliers for the next coming week is always set on Thursday the previous week. Before placing an order with suppliers, the transport planner needs to forecast the expected consumption of pallets during the following week. Established standards regarding how to perform forecasts related to the ordering of pallets does not exist and no tools are used to facilitate the creation of a forecast. Traditionally, employees who's had the responsibility of ordering pallets has based their calculations on their "gut feeling", as they have expressed it. However, lately a bit more structure has been dedicated to the ordering process by the employee responsible of the task. Thus, decisions regarding the ordering of pallets are based on calculations of the current week's demand and modified depending on aspects related to the demand. These aspects are reflected by known information of planned machine stops in production or if there is any identifiable trend. This was the case during the previous year, where consumption decreased due to the disassembly of a machine in order to make room for a more effective machine. More specific, an inventory check on pallets is completed by the transport planner before placing orders to suppliers. By knowing how many pallets are stored in the warehouse before the ordering point increases the insight of the consumption during the week, facilitating the forecasted demand of the coming week.

Pallets are ordered from multiple suppliers that are predetermined. The majority of these suppliers have an agreement with the SCA Edet mill, which forces the mill to prioritize the already established suppliers when placing orders. Suppliers delivering pallets to the mill is located both in the domestic as well as the foreign market. Consequently, besides ordering pallets from the domestic market deliveries originates from Denmark and Norway. Pallet suppliers consists of both LSPs as well as customers. Usually, the majority of the pallets are ordered from LSPs, 67 % in 2016. Here, orders are placed through sending an email to the LSP stating the number of pallets needed from a specific supplier. After the supplier has managed to collect the number of pallets, a confirmation of the booking is sent to the SCA

Edet mill stating the exact number of pallets that will be delivered. Thus, often the number of pallets delivered deviates from the ordered quantity due to restrictions related to the truck's ability to carry a maximum quantity of pallets. However, the number of delivered pallets usually deviates with some hundred pallets, representing 2 % of the actual quantity from a certain LSP. Further, in the confirmation document the locations of where the pallets are delivered from is stated as well as which days to expect a delivery. Regarding deliveries from customers, the transport planner generally books these after placing orders with the LSP. In order to grasp the difference between pallets delivered from customers and LSPs, data shows that deliveries from customers represent 27 % during 2016. However, one problematic issue relates to the Norwegian customers, who can choose to return pallets during the week. These returns have not been taken into consideration by the transport planner at the SCA Edet mill since no information has been shared with the Norwegian customers before the booking of orders on Thursday. Also, due to the policy in place stating the customers right to return pallets, the SCA Edet mill does not possess the authority to decline these deliveries. Consequently, the number of delivered pallets exceeds the actual demand.

The transport planner visits the pallet warehouse early on Monday mornings in order to understand the rate of consumption during the weekend. Since no information is shared between production planners and transport planners, the ordered number of pallets cannot correspond to the expected consumption of pallets in production. Thus, when the transport planner calculates the number of pallets in inventory on Monday, an overview is gained regarding whether the number of ordered pallets will exceed the demand or if additional deliveries of pallets during the week needs to be ordered. Additional deliveries could result in rush orders from suppliers which would be translated in increased costs.

4.3 Pallet handling process

Upon delivery of empty pallets all trucks unload the cargo at the same location. The truck driver is responsible for unloading the truck, while the forklift driver checks the quantity of the delivery, checks the quality of the empty pallets, and signs the consignment note. When delivered, the pallets are stacked on top of each other yielding an 18-high staple. After signing the consignment note the forklift driver transports pallets to the sorting machine. The forklift driver is limited to transport maximum of 16 empty pallets between the delivery location and the sorting machine. Further, due to the sorting machine's takt time, the rest of the pallets in the delivery needs to be stored in the warehouse. Thus, after the sorting machine has been filled, the rest of the empty pallets are stored at predetermined locations, both inside the warehouse and outside the warehouse without any protection from the weather. When pallets have been processed through the sorting machine they are either transported with lanes to the production or made available for the forklift driver to be stored in the part of the warehouse storing approved pallets. The handling of empty pallets between the sorting machine and the storing in the warehouse is limited to 12 pallets. Further, when the sorting machine detects defected pallets they exit the sorting machine and the forklift driver decides whether these should be refurbished or disposed.

4.3.1 Standardized pallet handling process

Two established standards, related to the handling and storing of empty pallets were found relevant. One of the standards covers most of the inbound delivery process regarding empty pallets. For instance, the predetermined steps and activities associated with the reception of empty pallets are specified. Further, rules are stated within the framework of the handling and storing of empty pallets. Henceforth, this standard will be related to as Standard 1. After reviewing Standard 1 a comparison was made with the actual situation in the warehouse storing empty pallets. While Standard 1 claims that empty pallets are not allowed to be stored outside the marked lines in the warehouse, it was observed that this aspect was not met. Also, according to Standard 1 a limitation exists on the number of pallets that can be stored on top of each other. This limitation was often neglected as the storing of empty pallets both exceeded this limit at times and failed to achieve it. Further, empty pallets were incorrectly stored in front of the sorting machine as some kind of a buffer, waiting to be loaded onto the sorting machine. Figure 12 illustrates the design of the warehouse area and, more specifically, where empty wooden pallets are supposed to be stored and where they were actually stored.

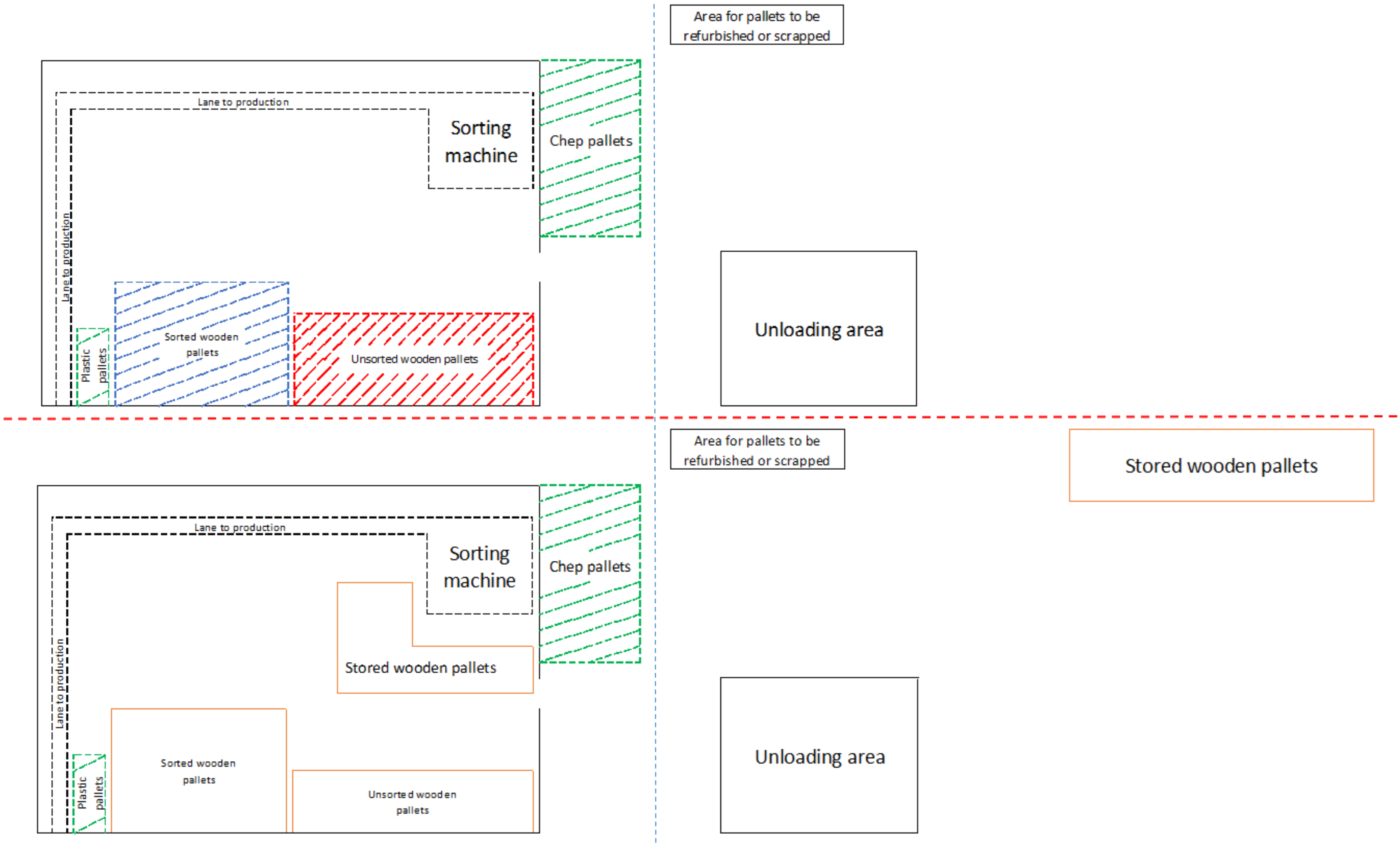

Figure 12: The structure of the pallet warehouse. The illustration above shows the supposed storage area of the warehouse. The actual storage of wooden pallets is depicted below.

The first part of the figure, depicted above the dashed red line, describes how the pallet warehouse should be structured according to established standards. However, the figure depicted below the dashed red line illustrates how the actual structure of the pallet warehouse looked like. It can be perceived as more pallets were actually stored in the warehouse, which is not actually true. In the actual situation, pallets were stored loosely with great spaces between sorted and unsorted pallets. Further, the areas highlighted to the right of the dashed blue line are located outside the pallet warehouse without any protection from the weather.

On the other hand, the second standard describes the sorting rules associated with the quality control of empty pallets, where various failure reasons corresponding to defective pallets are mapped, see Figure 13. This standard will further be related to as Standard 2. Observations on sorted and pallets were also performed to understand how well Standard 2 were complied. Further, the observations concluded that multiple defective pallets had been sorted and cleared as accepted. The lack of compliance with Standard 1 and 2 constitutes a major problem to the current inspection control process. Interviews were held to deal with this issue.

4.3.2 Errors associated with defective pallets

Inspected pallets at SCA Edet mill are perceived as defected if any of the errors, as illustrated in Figure 13, are present. The Vocational Training and Working Environment Council has created this guideline in order to achieve some form of standardization related to pallet exchange between a sender and receiver. Some of the largest operating haulers and LSPs in Sweden are connected to the council and follows its recommendations. However, these sorting rules are not enforced by law, allowing each receiver to ultimately set up their own rules regarding the acceptance of pallets.

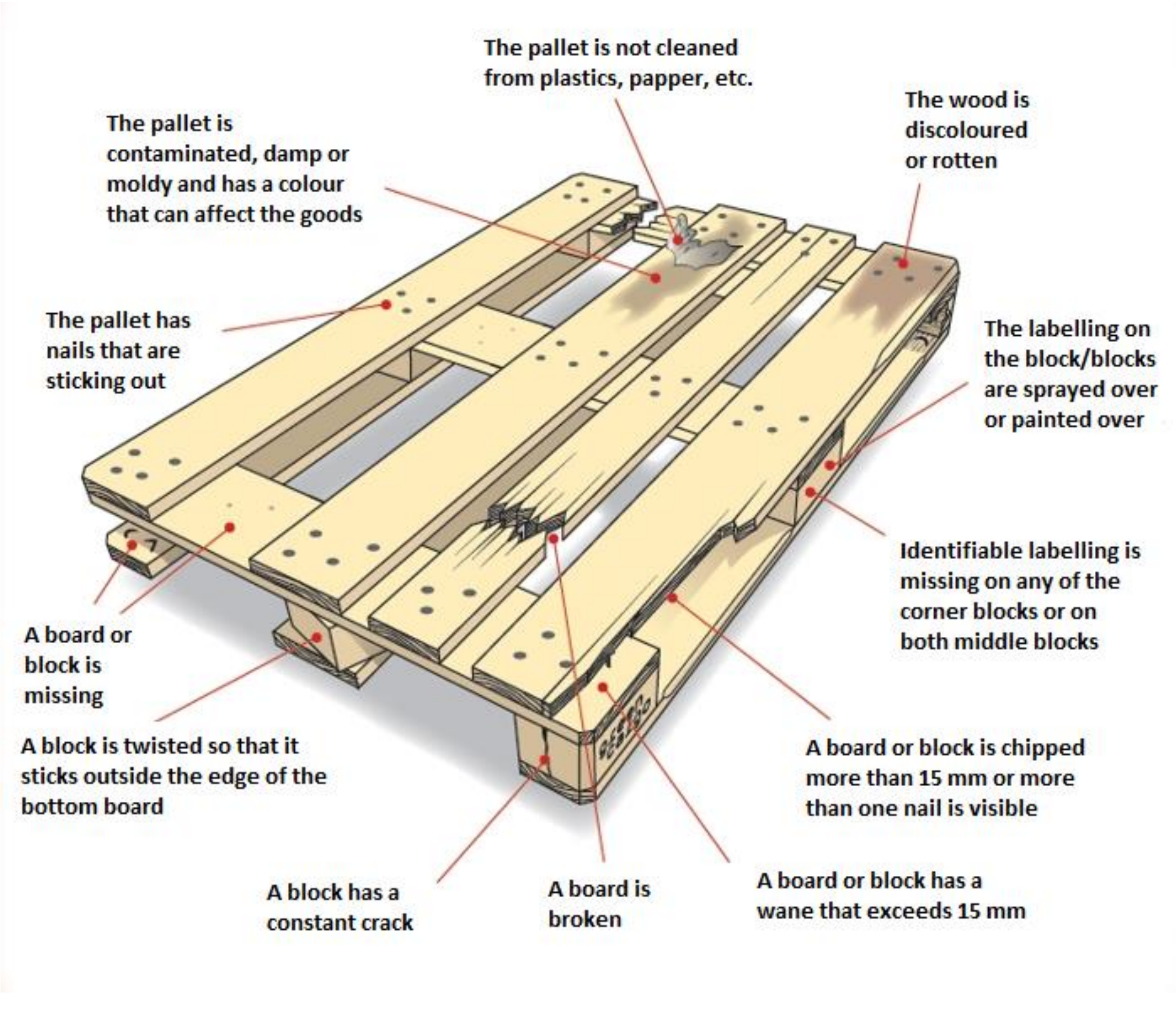

Figure 13: 12 errors that identifies a defective pallet, according to the Vocational Training and Working Environment Council in Sweden.

According to Table 5, the different errors have been given a number to facilitate the illustrations in figures related to this study.

Table 5: Numbers describing the different errors.

Error No.	Error
1	The wood is discolored or rotten.
2	The labelling on block/blocks are sprayed over or painted over.
3	Identifiable labelling are missing on any of the corner blocks or on both middle blocks.
4	A board or block is chipped more than 15 mm or more than one nail is visible.
5	A board or block has a wane that exceeds 15 mm.
6	A board is broken.
7	A block has a constant crack.
8	A block is twisted so that it sticks outside the edge of the bottom board.
9	A board or block is missing.
10	The pallet has nails that are sticking out.
11	The pallet is contaminated, damp or moldy and has a colour that can affect the goods.
12	The pallet is not cleaned from plastics, paper, etc.

4.3.3 Current inspection control process

From interviews with the forklift drivers, who in turn handles empty pallets on a daily basis, and observations it could be concluded that the current inspection process in place did not completely separate defective pallets from flawless pallets. One of the reasons adding up to the insufficient inspection control, was that the forklift drivers emphasized the difficulty to assess the quality of each pallet, when delivered in stacks of 18. As one forklift driver expressed it, "*it is a very general control process*" claiming that only obvious defects, such as missing blocks would be detected in this first screening process. This statement was further highlighted by another forklift driver, describing the difficulty to detect certain errors of the pallets due to the stacking, such as error 4, 5 and 6. Further, the interviews pointed to that trucks were at times unloaded without the forklift driver's confirmation of the consignment note, blaming this and the lack of documentation regarding defected pallets on the lack of time. As a result of this, the forklift driver's copy of the consignment note in most cases lacks the number of defected pallets for a certain shipment and lacks to a lower degree some type of signature, thus making it difficult to trace it to a certain employee. When asking the forklift drivers which of the errors that were easiest to detect, relating this question to Figure 13, the response was that "some of the errors are obvious, while others are very subjective". The same forklift driver further claimed that some of the errors, such as error 4 and 5 which relates to the tolerances of a crack, is difficult to measure precisely since the forklift drivers do not exit the vehicle to measure the crack. The driver further claimed that "*for instance my colleague approves all pallets, while other colleagues might perceive it as a defect*".

Further, interviews and observations showed that the reception of empty pallets, including the inspection control process, is only one of multiple tasks the forklift drivers are responsible for. Other tasks include emptying bins from production and supply outbound trucks with the right load. According to the job description the forklift drivers are supposed to allocate 30 % of their time on the handling of empty pallets. However, white-collar workers claimed that this was only figuratively and that the actual situation indicates a much smaller fraction allocated to the empty pallet process.

Another interesting aspect that emerged from the interviews was that all forklift drivers expressed concern over the sorting machine's ability to sort out all defected pallets. This issue had not previously been recognized by the management. Thus, an investigation of the accuracy level of the sorting machine was conducted in the context of this study. The investigation comprised 882 pallets and the sample were selected from different shipments and different suppliers during a period of three weeks. In order to measure the accuracy level of the sorting machine, pallets that have been processed by the machine were studied in order to detect any errors. The result of this investigation is presented in Figure 14. What can be concluded from the results is that the largest cause of errors is error 4.

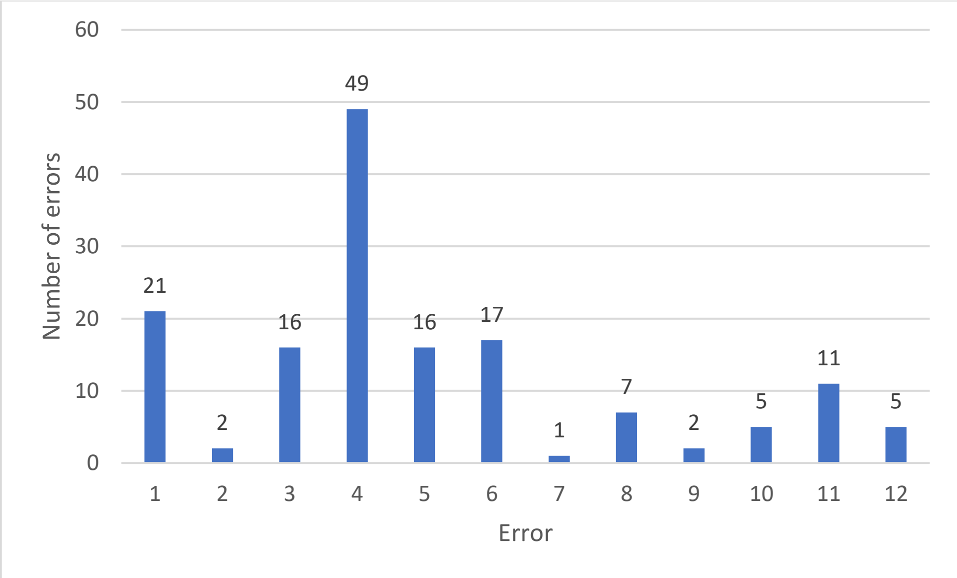

Figure 14: The result of an investigation regarding the accuracy level of the sorting machine.

Further, interviews were held with white-collar workers to understand their concerns regarding the inspection control process. One of the workers expressed concerns regarding the lack of documentation of this process. As the worker expressed it "*they [forklift drivers] are terrible at not writing the date the shipment was delivered and the number of defected pallets. I do not think it should be that hard to at least document the date and sign the consignment note the day the delivery was received. And that the employee who inspects, sorts and stores the load to document the number of defected pallets*". Other white-collar workers expressed concerns regarding the whole structure of the process. More specific, the idea to not notify the forklift drivers on the delivery time of the shipment was considered among several workers as problematic that resulted in all the stated weaknesses of the inspection control process. One of the workers claimed that "*when the truck does not notify in advance, both the management and the forklift drivers does not know the time of delivery. This results in an uneven workload, poor inspection control, and even more defected pallets, etc.*". Moreover, when a white-collar worker was asked about the high level of defected pallets at the customers site, claimed that "*perhaps we are only really poor at detecting defected pallets, that we are approving pallets that have been delivered defected to us and send them to customers who do not approve them*".

Moreover, multiple observations were performed in order to gain insight on the forklift drivers actual way of working. When observing the inspection control process the first time, a forklift driver was asked to show how the different activities were conducted. Several observations that followed after this were unannounced in order to prevent the forklift drivers from changing their actual way of working. By observing the forklift drivers, it became obvious that the initial inspection control that is supposed to screen the empty pallets upon delivery from suppliers before entering the sorting machine was almost extinct. Instead, several observations showed that the pallets are transported directly to the sorting machine. Further, forklift drivers did not exit their vehicle to inspect the delivered pallets. However, during one of the observations pallets with rather obvious defects, such as missing blocks, were separated from the rest of the pallets which entered the sorting machine.

Also, observations indicated that a small part of the delivery was dedicated to the sorting machine. As for the rest of the delivery, it was not stored inside the warehouse but instead stored outside without any protection from the weather. When the forklift drivers needed to access empty pallets to feed the production, they had to be stored inside before entering the sorting machine since the pallets were wet and frozen. The conveyor belt transporting empty pallets from the sorting machine to the production cannot move wet pallets since their surface would be too slippery. Further, complaints from the forklift drivers regarding this aspect related to increased processing times for the empty pallets. Also, they expressed concerns regarding the potential of increased defects resulting from the outside storing of pallets.

4.4 Storage and warehouse capacity

Shipments are not delivered during weekends forcing the staff to accept and receive deliveries exceeding the consumption of the working days in order to build inventory to cover for the consumption during the weekends. Consequently, the inventory levels in the warehouse reaches their highest point on Friday just before the weekend. Further, the time of delivery is not notified in advance. Instead, only a confirmation is sent the same day as deliveries of empty pallets have been ordered. The transport planning of trucks arriving to the SCA Edet mill are not evenly distributed during the five days of delivery, see Table 6. There is a large variation in the number of deliveries arriving each day. While some days the mill does not receive any deliveries of empty pallets, other days it receives up to five deliveries in one day.

Table 6: The delivery of pallets to SCA Edet mill during week 13, 2017.

Supplier	Monday	Tuesday	Wednesday	Thursday	Friday	Total
LSP 1	486	486,0	486	486	486	2430
LSP 2	561					561
LSP 3				561		561
Customer 1	561					561
LSP 4		2180		1680	1326	5186
Total	**1608**	**2666**	**486**	**2727**	**1812**	**9299**

The management desires to utilize a part of the empty pallet warehouse to store finished goods and has thus begun to store empty pallets outside in order to create area for the finished goods. As a result of this the majority of the empty pallets arriving to the mill are transported to predetermined area outside of the warehouse, after unloaded from the supplier's truck, as illustrated in Figure 12. The storage capacity was at first limited to 9 216 empty pallets in the warehouse. Due to the management's decision regarding the storing of finished goods almost half of the storage area has been dedicated to finished goods resulting in a drastic reduction of the number of empty pallets that can be stored, see Figure 15.

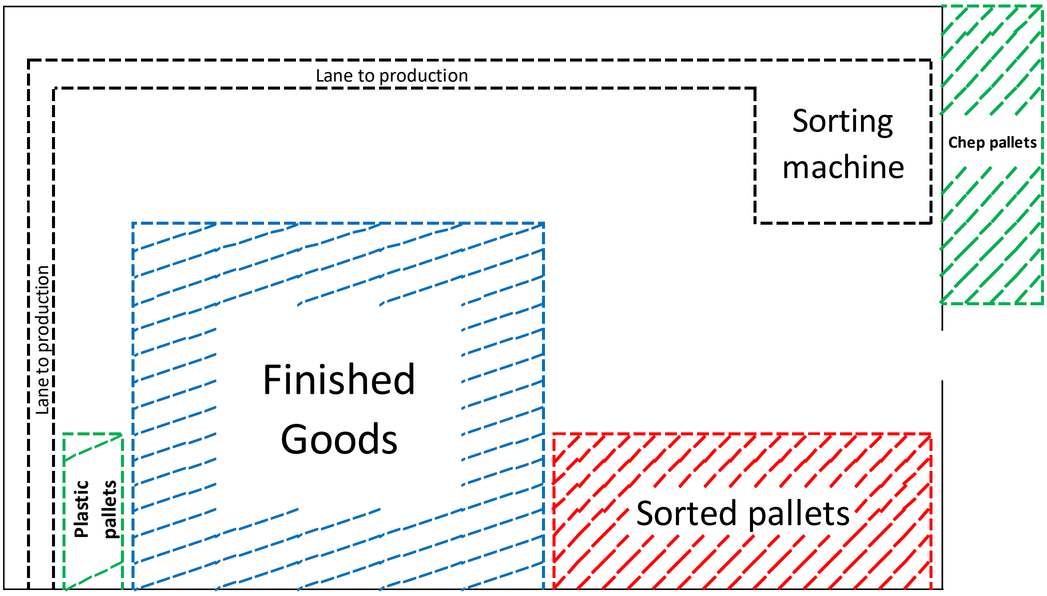

Figure 15: Structure of the pallet warehouse with stored finished goods.

Managing of the arrival of empty pallet deliveries are currently handled without any dedicated staffing. Instead, the forklift drivers handling this task are responsible for multiple additional tasks. When the truck has arrived the forklift driver receives a signal and needs to respond to this signal by leaving the current task and drive to the empty pallet warehouse, where the forklift drivers needs to sign the consignment note. In case of a high work load the forklift driver transports the empty pallets directly to the storage area outside. However, at times where the forklift driver is not too stressed an inspection control is performed and pallets loaded onto the sorting machine. The rest of the pallets are stored outside, while the sorted pallets are stored inside. Table 7 aims to describe the current handling process of empty pallet deliveries, whereas the total handling time for each pallet amounts to 50,2 seconds in which 20,2 seconds represent the total transportation time. Moreover, both interviews as well as observations have shown that allocated time by the forklift drivers on the handling of empty pallet is less than the expected 30 %, as illustrated by Figure 16.

Team leaders and forklift drivers responsible for the receiving and handling of empty pallets describes the process as "after loading a sufficient number of empty pallets onto the sorting machine one can disappear and take care of other tasks in the meantime". However, given that the sorting machine is perceived as the bottle neck of the process regarding the handling of empty pallets, it should be constantly running since one hour lost in the bottle neck is one hour lost in the system. Thus, observations showed that what the team leaders and forklift drivers implied did not correspond to the actual situation since the sorting machine were at several times observed as non operative. Due to this the management has requested suggestion of how the managing and handling of empty pallets can be staffed.

Table 7: Handling process related to inbound deliveries of pallets.

Activity	Number of pallets	Seconds	Second/pallet
Unloading area to sorting machine	32	30	0,9
Sorting machine	9	270	30,0
Sorting machine to storage (inside)	12	10	0,8
Sorting machine to area for scrapped/refurbished pallets	12	25	2,1
Sorting machine to storage (outside)	12	30	2,5
Storing to unloading area (inside)	0	13	13,0
Storing to unloading area (area for scrapped/refurbished pallets)	0	25	25,0
Storing to unloading area (outside)	0	30	30,0
Total			**50,2**
Transportation time			**20,2**

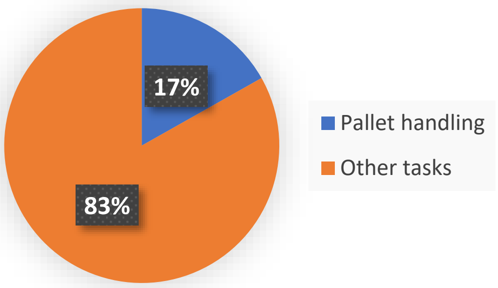

Figure 16: An illustration of the time spent on pallet handling in relation to the total working time.

4.5 Export pallet process

Exchanging pallets with foreign countries is based on a policy established by SCA, which should apply for all sales to foreign customers. When exporting products an invoice is automatically sent to the SCA sales organization in the foreign country containing the internal pallet price and the number of sent pallets. Thus, the foreign sales organization will credit its supplying subsidiary for the pallets carrying the goods. Further, the internal pallet price reflects the pallet price that SCA's controlling company has agreed on for all of its subsidiaries. Specifically, when firms within SCA exchange pallets or when exporting pallets, the receiving firm or sales organization is invoiced based on the internal pallet price. Several cost aspects have been considered when establishing the internal pallet price, see Figure 17.

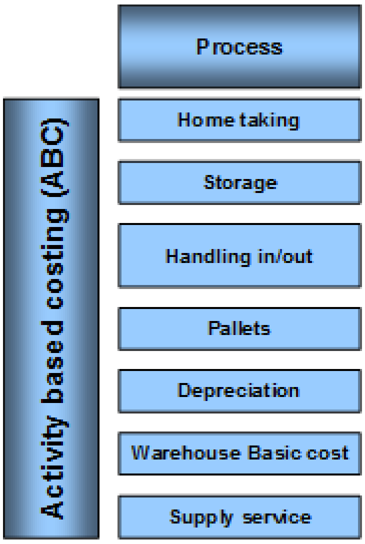

Figure 17:Cost aspects considered when establishing the internal pallet price.

Further, when customers return empty pallets to their nearest SCA firm or to the firm where the pallets originated from, the receiving firm will credit the corresponding sales organization for the number of pallets in good condition. The described principle regarding the pallet process for exporting applies for all subsidiaries. However, there are four exceptions to this principle due to differing regulations in some countries. One of these countries is Norway, which is covered in this study.

5. ANALYSIS

The chapter analyses the empirical findings based on the presented theoretical framework. It starts by discussing issues related to standards not being complied and continuous with analysing the design of the pallet warehouse. Finally, the flows to Denmark and Norway are mapped.

5.1 Storing locations not complying with standards

As emphasized in the empirical findings the majority of the pallets are not stored in the pallet warehouse. Instead, pallets are stored outside without any protection from the weather. This does not correspond to established standards locating the storing area to the pallet warehouse. Pallets have been stored outside before the decision by the management regarding storage of finished goods in the pallet warehouse. However, since this decision the number of pallets stored outside have increased continuously. During the early months of this year, the pallet handling process were perceived as even more problematic by the forklift drivers. As expressed in section 4.3.3, a chaotic situation emerged and pallets were placed unstructured all over the pallet warehouse in order to defrost them before entering the sorting machine.

Thus, the combined issues related to established standards not being complied, decision to allocate a part of the pallet warehouse to finished goods as well as unstructured inbound deliveries of pallets, the result has translated into outside storing of pallets. To understand the impact of these issues regression analysis have been conducted to establish whether a correlation exists between defect levels and weather. A regression analysis was conducted for each of the 12 errors illustrated in Figure 13 to investigate whether a correlation to the weather exists. The result of all the 12 regression analysis is presented in Appendix B. According to Gallo (2015) a correlation between independent and dependent variables is indicated if a trend clearly can be interpreted from the observations as represented by the inclined line in Figure 9. If, however, the plotted observations are not structured and located all over the plot, it can be concluded that no correlation exist between the variables studied.

Analysing the outcome in Appendix B, clearly all the regression analysis, except the ones related to error 1, 4 and 11, have their observations plotted in an unstructured way. As a result of this, it is possible to state that the errors represented by observations plotted all over the graph are not affected by the weather. Thus, the level of defects related to these errors does not increase or decrease whether if they are stored outside or in the pallet warehouse. Further, there are three errors that should be highlighted according to the conducted regression analysis, as presented in Figure 18. A clear relationship between the number of errors and the weather is illustrated, in which a conclusion can be drawn that with a decreased temperature the level of defective pallets related to error 1, 4 and 11 increases.

The obtained result's relevance of the regression analysis related to error 1 is perceived as high. The observations and quantitative data collection were conducted during the first months of 2017. Thus, the pallets stored outside were exposed to snow and rain, which resulted in wet pallets. When wood or timber becomes wet it starts to get a different colour than the clear bright colour represented by fresh wood and it also starts to rotten quickly. Due to wood's natural reaction when exposed to snow and rain, it becomes clear that the level of defects related to error 1 will increase when stored outside. Also, the result related to the regression analysis of error 11 can be related to the same cause. Lastly, an explanation to the correlation between weather and error 4 relates to frozen pallets. Materials subjected to a cold environment are more vulnerable to cracks in the material. Thus, when pallets are stored outside in low temperatures the pallets solidify and when the pallets are subjected to handling activities cracks quickly emerges.

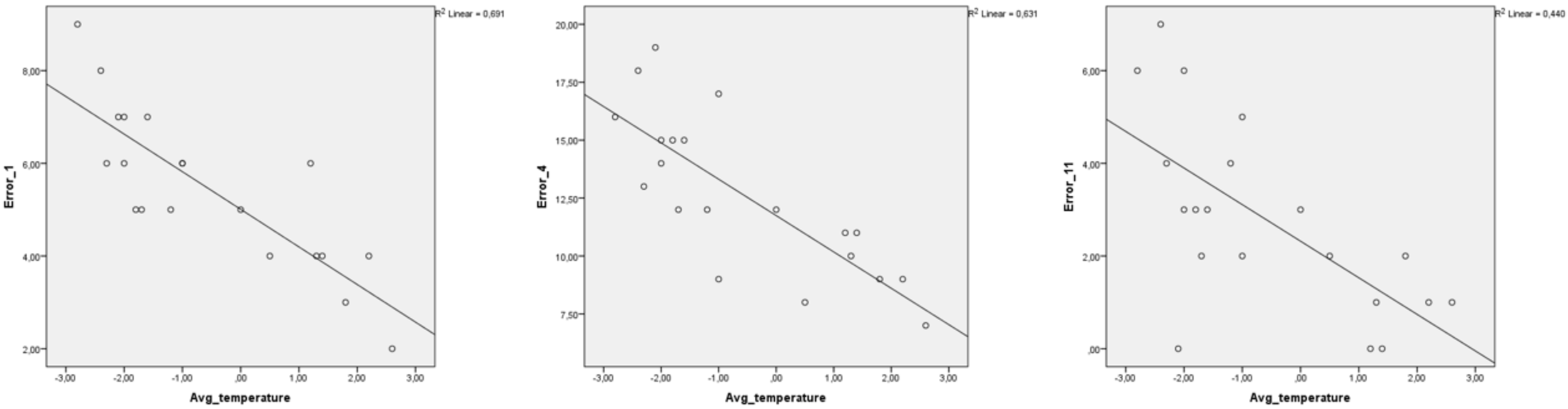

Figure 18: A correlation between defect levels and weather is indicated for three errors.

Table 8 highlights the correlation of determination, which describes the percentage of the response variable variation explained by the linear regression analysis.

Table 8: The correlation of determination stated for the three errors presented in Figure 18.

Error #	R^2
1	0,691
4	0,631
11	0,440

5.1.1 Information sharing in the pallet handling process

One of the major obstacles to a well-functioning inspection control process relates to the lack of information sharing between the truck carrying the delivery and the receiving firm, in this case SCA Edet mill. When an order of empty pallets is placed with the supplier, a confirmation is sent back to the firm containing information on when and how the order will be delivered. Thus, both white-collar workers as well as the forklift drivers are informed on the day of delivery for shipments of empty pallets from suppliers. Despite the sharing of this information it is still not sufficient for the forklift drivers to complete their tasks effectively. Since the forklift drivers are responsible of multiple tasks, whereas the empty pallet handling process is one of them, it makes it difficult for them to plan their time on the different activities if the exact time of the delivery is not shared. As a result of this, the workload often becomes high and uneven. In specific, the large variety in workload is very problematic as it leads to the forklift drivers becomes very time pressured when a delivery arrives. Thus, when time pressured the forklift drivers only focus on completing their tasks as fast as possible, which contributes to sacrificing quality in order to obtain more time. Consequently, the actual time spent on inspection control is reduced in order to keep up with the other tasks. This can be related to the theories of Megaw (1979), who describes the lack of inspection time as one reason that impacts the detection of defects. Nevertheless, in order to improve the inspection control process, some conditions that aims to increase the ability to plan in advance needs to be established. It is of essence to agree with the logistics service provider to let the truck notify in advance the expected time of delivery. If this is achieved, the forklift drivers will be able to spend more of their time on the handling and inspection of empty pallets, which ultimately would result in an improved inspection control.

Despite that the information already shared is not sufficient for the forklift drivers, it often is enough for the white-collar workers responsible for the administrative part of the process. This can be related to that white-collar workers, after placing the order of empty pallets, have completed their task of the process and it becomes the forklift drivers' responsibility now to receive, inspect and handle the process. Thus, the white-collar workers are not directly affected if the truck does not notify in advance the expected time of delivery. However, since these workers have started raising awareness of this issue due to the high level of defects on pallets reported by customers, managers have realized that the lack of information regarding the exact time of delivery, might not have a direct impact on them but an indirect impact instead. As emphasized by Narayanan and Raman (2004), if a firm does not have any insight in another firm's activities, who operates in the same supply chain, it becomes problematic to ensure an alignment of the supply chain. Further, Debo et al. (2001) relates to this by claiming that it is not only firms to firms, but often firms within themselves. Consequently, in relation to these theories this has presented incentives for the white-collar workers to actively be involved in increasing the information sharing between pallet suppliers and receiving firm in order to improve the alignment within the firm and the forklift drivers.

5.1.2 Providing opportunities for feedback

Another obstacle affecting the outcome of the inspection control process relates to the lack of documentation on received deliveries of empty pallets as well as on the consignment note. The number of defected pallets delivered are not constantly documented, in fact, only a fraction on the number of defected pallets per delivery are documented by the forklift drivers. As a result of the incomplete documentation any comparison between shipments from suppliers becomes difficult. If the management wishes to compare the level of defected pallets from two different shipments from the same supplier it becomes difficult due to the incomplete documentation. The same goes for shipments from different suppliers. Thus, without any complete documentation that the management can base their decisions on, the allocation of resources will not fulfill the demand. This will be the case since the lack of documentation leads to managers not being able to focus their efforts on actual problems. Consequently, suppliers repeatedly sending deliveries with a high level of defective pallets will be addressed in the same way as suppliers who delivers approved shipments. Chabukswar et al. (2003) emphasizes the essence of feedback as a driving force to an improved visual inspection process, claiming that gathering and documenting of data works as a facilitator for reducing the level of defects. As can be retrieved from the theories of Chabukswar et al. (2003) the essence of feedback in terms of continuous documentation of a certain process reveals great opportunities to allocate resources effectively and address problematic issues. Both managers and forklift drivers could benefit from receiving feedback on their efforts. By continuously documenting each delivery with the number of defects managers will be able to compare and track the quality of each delivery as well as deliveries between different suppliers. This will allow the management to address suppliers with repeatedly high level of defective units and provide opportunities for measures that can be aimed at the suppliers, leading to suppliers being subjected to an evaluation. Further, a continuous feedback will allow managers to monitor the quality level of the deliveries making the process more controllable and hence preventing it from getting out of hand. Firstly, by monitoring the process deliveries within a certain level will be approved. In case deliveries deviates from the agreed level, they will be detected directly and addressed. Secondly, a continuous data gathering provides opportunities for improving the process. With a continuous feedback regarding the quality level managers can use this to jointly work with the suppliers towards a reduced level of defected units. By sharing such information with suppliers will not only raise awareness of the process but also emphasize the essence of improvements, ultimately leading to an increased quality level.

From the perspective of the forklift drivers, continuous feedback will allow the drivers to evaluate their effort of detecting defective pallets. By monitoring the level of defective units per shipments and comparing these to the maximum level of defective units as has been agreed between firm and suppliers, forklift drivers can use this information to improve their efforts in order to reduce the defect level to the agreed level. Having the data documentation continuously presented to the forklift drivers, in real time mode, will provide constant feedback as well as present opportunities to continuously improve the detection of defects. Further, as claimed by Narayanan and Raman (2004) incentives from the management aimed to facilitate the improvement work needs to be present. In order to involve the forklift drivers into actively working towards continuous improvement, only presenting real time feedback is not sufficient, instead management needs to establish goals and rewards for the forklift drivers.

5.1.3 Improving the process of detecting defective pallets

Further, Marie et al. (2015) claims that providing controllers with access to illustrations of the defects can help improve the inspection control process. Due to forklift drivers does not exit their vehicle to evaluate potential errors of the pallets, any assessment of errors relating to cracks that are bigger than a certain minimum becomes difficult. This increases the variation in reproducibility among forklift drivers leading to that the same errors are approved at times and not approved by others. An easy access to illustrations of the errors would facilitate the detection of errors and foremost the evaluation of errors, while improving the understanding of the errors among forklift drivers. Thus, in case of difficulties in deciding whether to approve a certain pallet or not, the illustration will help make the decision as it includes all the possible errors resulting in a defective pallet, see Figure 13. Moreover, it will reduce the hesitation of whether to approve pallets or not as well as reduce the variation between different forklift drivers. However, a complete elimination of the variation will not be achieved due to that different drivers still interpret illustrations, words, symbol, etc. differently. Regardless, an illustration such as the one described is the first step towards gaining more control over the process as well as increasing the understanding of the forklift drivers relating to the different errors. An illustration of the errors should be placed in an easily accessible area near the area of inspection control. Thus, the pallet warehouse is a recommended place for it, making it easily accessible through placing it on one of the walls. It should be noted that the forklift drivers' as well as team leaders and warehouse manager's opinions were included in deciding where to place the illustration. The illustration will be represented in a large plate, making it accessible across the whole pallet warehouse. Thus, when insecurity appears regarding the approving of certain pallets, forklift drivers will be able to make a decision by looking at the illustration.

5.2 Future pallet demand

By studying the graph in Figure 10, a constant reduction in consumption of pallets during previous year is clearly indicated. This negative trend does not represent a declined surge of demand from customers, instead it can be related to the disassembly of a converting line in order to make room for another more productive converting line. The converting line is the last step of the paper process where large paper rolls are processed to customer products. Since week 40, the new converting line has been operating, illustrated as an increase in consumed pallets, see Figure 10. An increase in productivity is expected to be realized by the new converting line and a consumption of approximately 14 000 empty pallets each week is forecasted. However, this level of productivity will be delayed since it takes time to trim the converting line and set the different machine settings to the right values. Accordingly, the mentioned level of consumption is a potential future state and not the current state. Since the consumption of empty pallets during the previous year is not directly accurate to base future calculations on, the highest value in the graph has been selected as a reference point since it represents a good measurement and a more accurate value to base the calculations on. As illustrated in Figure 19 the demand that the calculations have been based on is highlighted. Consequently, the daily average consumption of corresponds to 1 931 pallets and the inventory building to cover for the demand during weekends reaches 3 862 empty pallets on Friday.

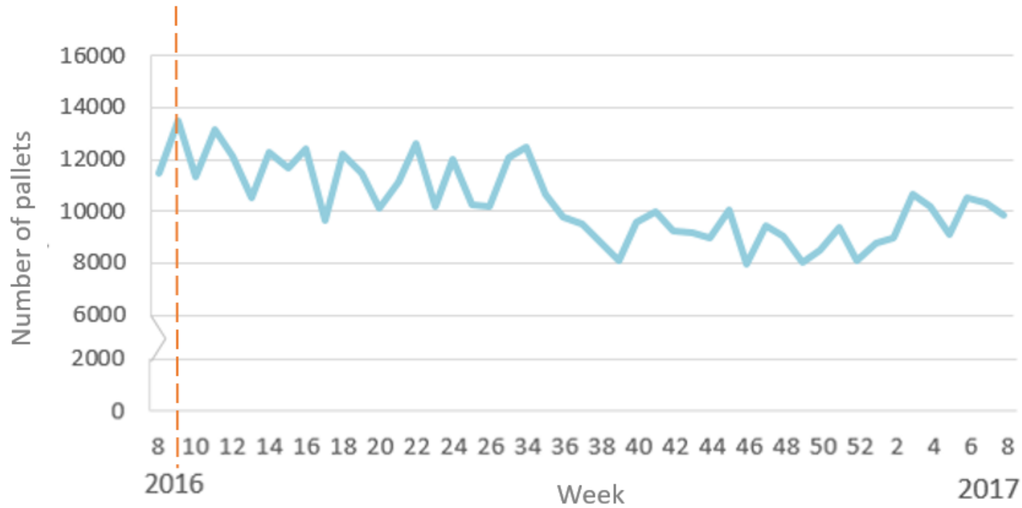

Figure 19: The dashed red line shows the consumption rate the calculations have been based on.

5.2.1 Restructuring the pallet warehouse

The current structure of the pallet warehouse is not optimal from the perspective of wooden pallets, thus possessing a potential for improvements related to the pallet handling process. Figure 20 illustrates a suggested new structure of the warehouse, which can be compared to Figure 15, where the current structure of the warehouse is presented. Redesigning of the pallet warehouse is based on third step of the framework presented by Elia and Gnoni (2015).

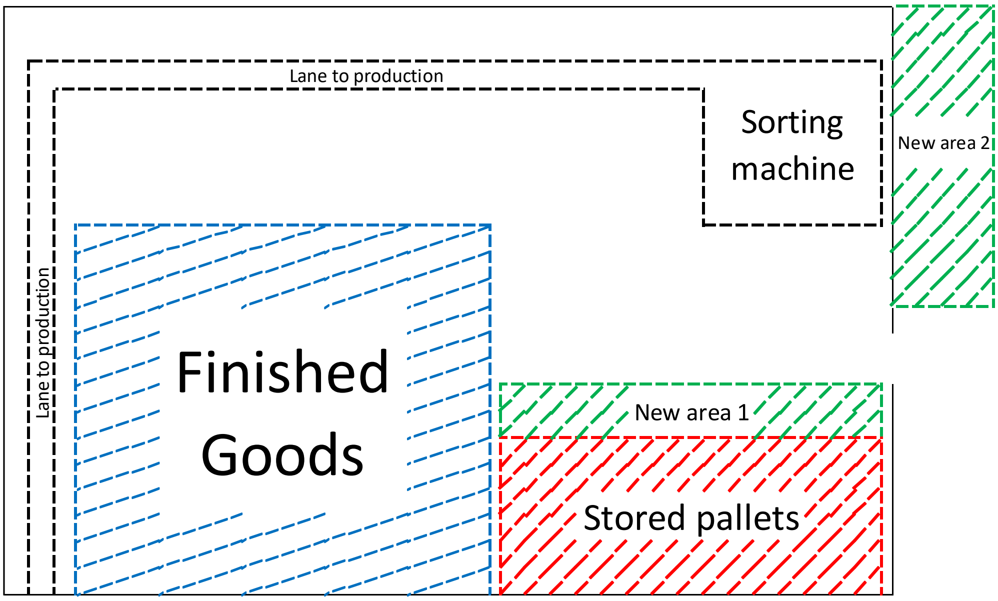

Figure 20: New structure of the pallet warehouse.

Three changes to the structure are suggested that aims to dedicate the area closest to the unloading area for the handling and processing of empty pallets. Changes related to *new area 2* aims at removing the type of pallets currently stored at this area, in order to make room for wooden pallets. Pallets currently stored at the area are CHEP pallets, which are low frequent pallets requiring an order of approximately 500 pallets every three month. Further, the current storage area for the CHEP pallets is not in direct connection to the location of use. Recently, carton boards used as packaging material for products has been phased out, which automatically has created available storage space. This space is located closer to the location where CHEP pallets are used, allowing them to be stored in the carton boards' place. Consequently, *new area 2* in Figure 20 will be cleared from CHEP pallets. When receiving deliveries of CHEP pallets, approximately 600 pallets will exist in inventory utilizing half of the area previously used to store carton boards.

Changes to the warehouse states that plastic pallets will be removed due to the same reasons as the CHEP pallets, which is due to low frequency. As argued by Guzman-Siller (2009) plastic pallets can withstand wind and weather better than wooden pallets, which if the management take the decision to store them outside should not result in defective plastic pallets. Further, changes associated with *new area 1* in Figure 20 indicates that the current limitation lines will be moved forward, allowing an increase in the number of pallets stored. This suggestion has been developed in close cooperation with forklift drivers, team leaders, warehouse manager, and logistics manager in order to not impede on the safety as well as on the ability for the forklift drivers to perform their tasks. If all these changes are completed storage space will be made available, allowing for a more effective handling process of wooden pallets. When storing pallets, the different areas needs to be prioritized according to the following. Unsorted pallets should be stored in *new area 2* and sorted pallets in *new area 1*. However, in order to achieve a small area as possible to store the pallets, it is essential to always have a filled lane with pallets to production.

An example of this relates to the unloading process of arrived deliveries. The current structure allows the forklift drivers to store received empty pallets outside in the area illustrated in Figure 12. An analysis of the activities related to this process is expressed in Table 7 where the total transport time amounts to 20,2 seconds. However, by implementing the new structure and storing the received empty pallets in the warehouse as well as in *new area 2* would reduce the total transport time to 15,3 seconds, see Table 9. Relating the difference in transportation time to the number of pallets handled during a year, time savings due to reduced distances amounted to 31 days will be possible to achieve. It should be noted that the total seconds per pallet are weighted based on the percentage of pallets stored at the different areas.

Table 9: Activities related to the pallet handling process regarding the new design of the pallet warehouse.

Activity	Number of pallets	Seconds	Second/pallet
Unloading area to sorting machine	32	30	0,9
Sorting machine	9	270	30,0
Sorting machine to storage (inside)	12	10	0,8
Sorting machine to area for scrapped/refurbished pallets	12	25	2,1
Sorting machine to storage (outside)	12	10	0,8
Storage to unloading area (area for scrapped/refurbished pallets)	0	25	25,0
Storage to unloading area (inside)	0	13	13,0
Total			**45,3**
Transportation time			**15,3**

5.2.2 Increased warehouse capacity

As mentioned in the previous section, not only is there no dedicated staff handling the empty pallet process, but the actual time spent on handling this task is much less than the expected 30 %. Figure 16 visualized this by showing the amount of time being allocated to the pallet handling process, by the forklift drivers. An investigation of different staffing alternatives has been completed. Alternative 1 represent dedicated staffing in terms of one coordinator during daytime. More specific, the coordinator is supposed to only handle the empty pallet process during 8 hours per day for five days a week. One dedicated coordinator would increase the staffing costs without leading to a considerably reduced inventory level. It would still be required to store empty pallets in the pallet warehouse, since *new area 2* would not be sufficient. Also, the workload related to the handling and storing of empty pallets is not sufficient to require a dedicated coordinator on full time. Despite a future scenario with a consumption of 14 000 empty pallets per week it would result in a lack of tasks for the coordinator between received deliveries and the waiting time that arises when the sorting machine processes empty pallets. Thus, the operative efficiency of the dedicated coordinator would not be sufficient due to the idle times.

The second alternative ensures a 30 % time allocation by two shift workers during the week. In this case, no dedicated staffing will be required and the task will be divided between two workers. One worker will handle the process during the morning shift and will later be relieved by another employee who works the afternoon shift. Thus, empty pallets will be processed during a period of 16 hours per day instead of the 8 hours as presented in the first alternative. It will be possible for the forklift drivers to achieve a capacity of 1 536 processed pallets per day. However, the two shifts work only five days a week forcing the three shift workers to handle the empty pallets during the weekends. Thus, the capacity will decrease on weekends due to the three shift workers not being able to allocate the same amount of time on the handling of empty pallets. The benefit of this alternative is that costs related to staffing will remain the same as the current situation since it is stated that two shift workers are supposed to allocate 30 % of their operative time on the handling and processing of empty pallets. Thus, if management can ensure a 30 % time allocation a better outcome will be achieved by using the current resources in a more effective way. Despite, that the inventory level will decrease to a lower level than the previous alternative, *new area 2* does not possess enough space to store unsorted pallets. However, by ensuring a certain level of time allocation to the handling and processing of empty pallets could become a cause for a high workload. More specific, in situations where a forklift driver experiences unexpected problems usually result in an increase of the workload.

The third alternative presented aims to combine the benefits of the two previously mentioned alternatives. As a result of this, the third reason is represented by one coordinator and two shift workers. However, the coordinators task should not be perceived as similar to the one described in alternative one. Instead, the coordinator will only be responsible for receiving deliveries of empty pallets. That is, the tasks include signing the shipping note and approve the quantity and quality of the delivery. This task is expected to take 10 minutes of the coordinators time and during a working day amount to approximately 40 minutes. Consequently, staff will not be employed only for this task. Instead, by making time available of a relevant worker, for instance team leader, will allow this worker to take on the role as a coordinator. After the delivery has been received it is the two shift workers' responsibility to process the empty pallets through the inspection control process. Since the coordinator clears the paperwork, the two shifts will be able to spend their time more effectively on the processing of the empty pallets. Thus, the two shift forklift drivers will be able to add five more minutes to the handling and processing of the empty pallet process, which will result in an achieved capacity of 2340 pallets per day. However, in this case the sorting machine becomes the limiting factor since it can only process approximately 120 pallets per hour. Due to this a more accurate capacity level should be 1 920 pallets, as illustrated in Table 10. Despite this slight reduction in capacity, when the inventory of empty pallets is the highest it will be possible to keep the unsorted pallets in *new area 2* and, hence, dedicating the pallet warehouse to sorted pallets only.

Table 10: A comparison between the capacity levels for the different staffing alternatives.

Alternative	Description	Capacity (no. of pallets)
1	Coordinator on daytime	≤ 1 108
2	2-shift workers (30 % time allocation)	≈ 1 536
3	Coordinator + 2-shift workers	≥ 1 920

5.3 Mapping of the flow to Norway

Both the AFH and consumer tissue segment to Norway has been perceived as problematic due to different reasons during the years. Regarding the consumer tissue segment, conditions of the pallet pooling system has not been understood properly by the management which has resulted in increased costs. On the other hand, issues related to the AFH segment concerns the lack of information between customers who return empty pallets and the mill.

When mapping the consumer tissue segment, it can be stated that a hauler and a LSP are involved in this flow. No pallets are ever under the ownership of the LSP, instead it only manages wooden pallets on the behalf of its customers. Regarding the cost structure of this flow the internal pallet price of 66,40 SEK is not used, instead the foreign sales organization receives an invoice of 27,91 SEK per pallet. This corresponds to the administrative fee of using the LSP as well as the internal handling cost related to the mill in Lilla Edet. A further specification is that the administrative fee is related to the sender fee required by the LSP. Further, the foreign sales organization is subject to a recipient fee that amounts to approximately 8,90 SEK, according to the terms of the LSP. Both the sender and recipient fee relates to the outgoing and incoming stream of goods, in which the fee is paid for each pallet. The LSP collects pallets from customers after they have made them available for collection through the IT system. Further, by ordering empty pallets from the LSP in standard quantity and terms does not translate in a fee. However, since the LSP is located in Norway, a transportation cost needs to be paid by the SCA Edet mill, which in turn is reinvoiced to the foreign sales organization. Upon delivery of empty pallets by the LSP, SCA Edet mill credits the foreign sales organization with the total sum of 66,40 SEK per pallet. Under normal circumstances the total sum that is credited to the sales organization amount to the same sum that is being covered by the sales organization during the process. Figure 1 aims to describe the relationship between the mill, LSP and sales organization.

Since the agreement with the LSP is represented by a pallet pooling system, balance settlements are used to keep track of whether the customer, in this case SCA Edet mill, have ordered more or less pallets compared to the number of dispatched pallets. Customers who, during the period between two balance settlements, have provided a net addition of wooden pallets to the NLP system by registering more wooden pallets out of its account than into its account, will have a negative balance. Customers who, during the period between two balance settlements, have received a net addition of wooden pallets from the NLP system by registering more wooden pallets into its account than out of its account, will have a positive balance.

Balance settlements are made at the end of every two calendar months, i.e. the last business day of February, April, June, August, October and December. When balance settlements are carried, settlements of accounts are calculated. For a negative balance, this means that the Customer will sell to NLP the number of wooden pallets corresponding to the size of the balance. For a positive balance, this means that the Customer will pay NLP for the number of wooden pallets corresponding to the size of the balance. In connection with the above settlement, a credit note or invoice will be issued to the Customer.

The wooden pallet surplus fee is calculated monthly. In case of a negative balance, for Wholesalers this means that the Wholesaler has supplied the NLP system with a greater quantity of wooden pallets than the Wholesaler has received with the flow of goods from Suppliers that are Customers, or from NLP. For this wooden pallet surplus, no Sender or Recipient fee has been paid. There are costs for NLP related to these wooden pallets, and to compensate therefore, Wholesalers with a negative balance have to pay a fee for each surplus pallet, corresponding to the total of Sender and Recipient fees (referred to as Surplus fee). The surplus fee is invoiced monthly. If a Wholesaler has accrued a positive balance, this may be set off against a later negative balance before the calculation of the surplus fee.

The flow regarding the consumer tissue segment can be related to the theories of Lützenbauer (1993). The current system fulfills the conditions associated with a system which includes return logistics. The sender is not responsible for handling the return flow of empty pallets. Instead the central agency, which is the LSP in this case, carries the responsibility to transfer pallets between the senders and receivers. Specifically, the system in place reflects a depot system with a book system, despite monetary flow in the system. As understood from Lutzenbauer (1993) the deposit system includes monetary flow based on the value of the pallets. This is not the case for the system related to the consumer tissue segment to Norway. Indeed, there are monetary flows between the actors in the network. However, these are related to the fees required by the LSP and based on the administrative, handling and transporting costs and not on the value of the empty pallets. Due to this, the system is perceived as a depot system with booking.

Further, according to Gnoni and Elia (2015), the pallet management system can be described as a closed loop network. Due to the agreement with the LSP establishing that SCA Edet mill needs to dispatch empty pallets in order to keep the balance in check, a return flow arises resulting in the design of a closed loop network. Further, the return flow of empty pallets is not offered urgently, instead the downstream firm decides when to make empty pallets available for collection by reporting them in the IT system of the LSP. Thus, the structure of the return flow is based on a postponed interchange since the downstream firm does not issue a pallet voucher immediately. According to ECR (2006), the LSP states time limitations for when the downstream firm needs to make empty pallets available for collection as well as penalty costs related to the inability to supply the LSP with a correct number of empty pallets.

The AFH business segment, on the other hand, is not represented by a pure pooling system. Instead the pallets are sold to customers and after unloaded from goods the receiver decides whether to return the empty pallets back to the mill. The Norwegian customers place their order with their corresponding sales organization, who in turn communicates them to the mill in Lilla Edet. Products are then transported to customers who are invoiced for the goods and pallets. Due to the policy SCA has regarding empty pallets customers have the right to transport pallets back to customers, in which the receiving firm compensates the customers for the price of the pallets. The complexity in this flow is rather low in comparison to the pallet pooling system as the one established with the consumer tissue segment, as emphasized by (Elia and Gnoni, 2015).

As stated the system related to the AFH segment to the Norwegian market is not associated with an established return flow of empty pallets. The receivers decide whether to keep their pallets or to use the option to return the empty pallets to the sender. Since the return flow is not mandatory for the customers and instead an opportunity offered by SCA the system cannot be reflected by a pallet pooling system. Instead this pallet management strategy can be related to the open loop system as described by Elia and Gnoni (2015). When goods are shipped to customers the sender invoices the receiver for the full value of the pallets. Further, in case empty pallets are returned to the sender the receiver is credited for the full value of the empty pallets returned. Thus, the pallets are sold to the receivers and repurchased by the sender based on the receivers' decision to return pallets. Following this statement, the system should be perceived as a sales system and not a pallet pooling system.

5.4 Mapping of the flow to Denmark

According to the management as well as white-collar workers the flow related to the Danish market is less complicated compared to the flow to Norway. Both the consumer tissue segment as well as the AFH segment to Denmark are handled by the same LSP, which is responsible for maintaining a balance between pallets ordered from the LSP and pallets shipped to the Danish market. Thus, a contact person at the LSP continuously communicates the balance and suggests the number of pallets to be ordered by SCA Edet mill in order to keep the balance under control. Further, this pallet management system is not a pure pallet pooling system since monetary flows are involved. The sender invoices the outgoing pallets to the sales organization in Denmark and credits the incoming empty pallets. Following, a transaction is made between the sales organization and the LSP. Since this market is not subject to the exceptions of the export process as emphasized in section 4.5, the internal pallet price is used. Thus, transactions between the different actors in the network are based on the value of the empty pallets. Ownership of the pallets are transferred between the SCA Edet mill and the sales organization in response to the transactions. Consequently, the LSP only manages the transportation, storing, and collection of empty pallets in this system.

Since this pallet management strategy is rather similar to the consumer tissue segment to Norway, in terms of the type of structure it can be reflected in a system which includes reverse logistics as described by Lutzenbauer (1993). In this case, the LSP provides storage of empty pallets at predetermined locations and from these locations empty pallets are delivered to the sender based on orders. Further, after the collection of empty pallets from the receiver they are transported back to the location by the LSP and stored until needed by the sender. This corresponds to Lützenbauer's (1993) studies of depot systems, where empty pallets are stored in depots awaiting orders from the sender. Due to the monetary transfers between the actors on the value of the empty pallets makes this system corresponding to the deposit system. However, an exception to Lutzenbauer's (1993) description of the deposit system is that these flows does not represent monetary flows to the LSP since they do not take over the ownership of the empty pallets. Clearly, there exist transactions between the LSP and the sales organizations but these are not based on the value of the empty pallets and should be perceived as fees or costs for performed activities.

Relating both these flows to the theories of Elia and Gnoni (2015) a clear reference to the closed loop network can be drawn. Here, a closed loop is relevant due to the existing of a return flow of empty pallets to the sender. When the senders' ships pallets carrying goods to receivers they are not obliged by the LSP to dispatch empty pallets in connection with the outgoing flow of pallets. Instead, the LSP allows for a postponed interchange leading to that the sender decides when to dispatch deliveries. Also, as described by ECR (2006) time limitations regarding when the sender needs to dispatch empty pallets from the LSP is present in the agreement related to the flows to Denmark.

6. CONCLUSIONS

RQ1. Is the current inspection control process regarding received deliveries of empty pallets complying with established standards and routines?

There are major weaknesses in the adherence of standards and routines associated with the inspection control process. Pallets are not stored according to established areas and instead stored outside, where they are exposed to the weather. Information is not shared between suppliers delivering pallets and the SCA Edet mill, which leads to resources not being used effectively. Further, the documentation of the deliveries is insufficient and the number of defective pallets from suppliers are not noted. In order to improve, management needs to realize the impact of not complying with established standards and, hence, storing empty pallets outside during the winter months. Conducted regression analysis indicates that some errors related to pallets are directly correlated to the temperature.

RQ2. When based on actual demand, how should the inbound delivery of empty pallets be structured and managed?

The pallet warehouse is not optimal from wooden pallets point of view, which leads to longer transportation distances and, hence, a less efficient pallet handling process. A redesign of the pallet warehouse has been completed, in which the areas closest to the unloading area have been dedicated to the wooden pallet handling process. New areas in the pallet warehouse have been created by the redesign allowing the pallets to be stored using 70 square meters less in the pallet warehouse. Further, the issue related to insufficient staffing capacity has been addressed and different staffing suggestions have been elaborated.

RQ3. How is the current pallet logistics designed regarding the tissue business segment to the Norwegian and Danish markets?

Regarding the consumer tissue segment to Norway, the current system fulfills the conditions associated with a system which includes return logistics. Specifically, the system in place reflects a depot system with a book system. Due to the agreement with the LSP establishing that SCA Edet mill needs to dispatch empty pallets in order to keep the balance in check, a return flow arises resulting in the design of a closed loop network. Further, the return flow of empty pallets is not offered urgently. Thus, the structure of the return flow is based on a postponed interchange since the downstream firm does not issue a pallet voucher immediately. Further, the AFH segment to the Norwegian market is not associated with an established return flow of empty pallets. The receivers decide whether to keep their pallets or to use the option to return the empty pallets to the sender. Since the return flow is not mandatory for the customers and instead an opportunity offered by SCA the system cannot be reflected by a pallet pooling system and should be perceived as a sales system.

Both the consumer tissue segment and AfH segment can be reflected in a system which includes reverse logistics. These flows correspond to a system characterized by a depot system, which is based on a deposit system. A clear reference to the closed loop network can be drawn and a postponed interchange is allowed in these flows leading to that the sender decides when to dispatch deliveries from the LSP.

6.1 Future work

In practice, this thesis contributes to the area of logistics system design related to pallets. SCA's reverse flow of pallets has been improved and issues regarding the implementation of open or closed loop logistics network has been addressed. Additionally, this thesis has contributed to the theory by providing data regarding the effect of storing wooden pallets outside without protection from the weather.

Suggested future work could be aimed at two different subjects. Firstly, further research would be relevant in the area of information sharing within SCA as well as with pallet suppliers. Currently, pallets are ordered for the next coming week before the production schedule for that week is set. As a result, fluctuations between ordered and consumed pallets will differ. It would be of interest to investigate this issue and together with pallet suppliers agree to either shift the deadline regarding ordering of pallets or to outsource this ordering process to the production department.

Secondly, from a theoretical perspective, potential future work could be aimed at investigating the correlation between storing pallets outside and the time they have been stored outside. According to this thesis, the outcome from performed regression analysis states that correlations exist between certain errors and the temperature. However, the time pallets have been stored outside is perceived as an essential factor in the outcome of approved or defective pallets. Thus, investigating the relation between these variables could enhance the current theory related to this topic.

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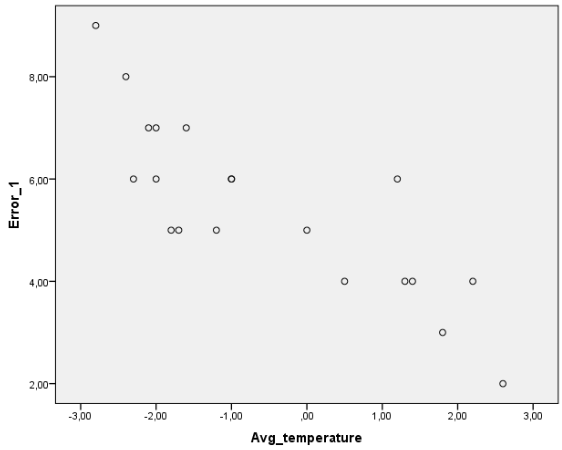
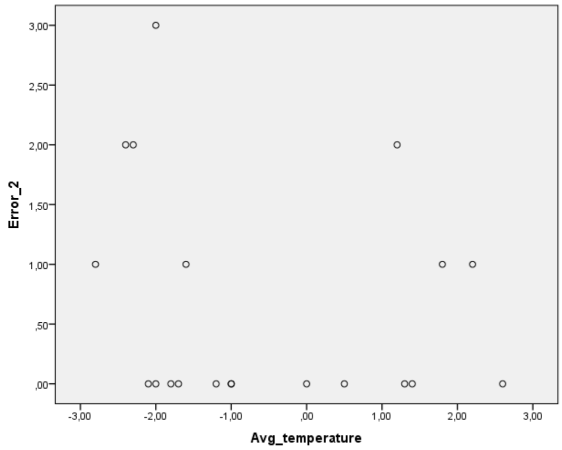
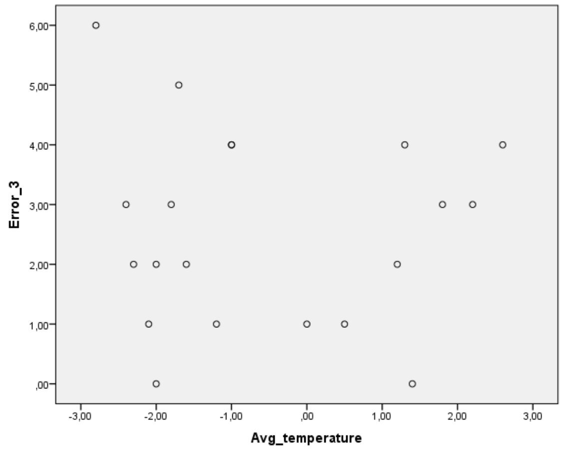
APPENDIX A

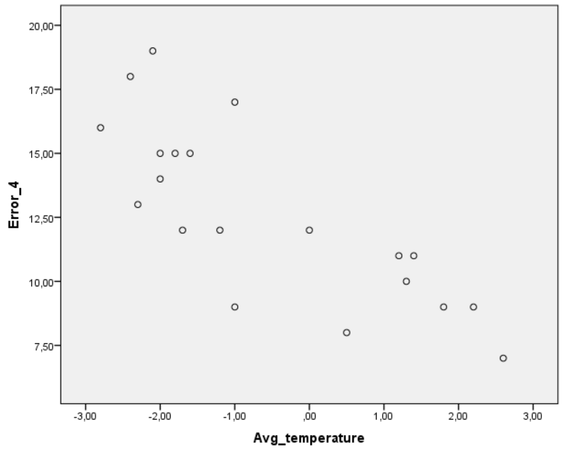
Observation	Pallets	Average tempterature	Error_1	Error_2	Error_3	Error_4	Error_5	Error_6	Error_7	Error_8	Error_9	Error_10	Error_11	Error_12
1	288	-1,6	7	1	2	15	2	5	0	1	0	2	3	0
2	234	-1,2	5	0	1	12	5	6	0	0	0	2	4	0
3	252	-1	6	0	4	9	4	3	2	5	0	1	2	1
4	279	-2,3	6	2	2	13	8	8	0	0	2	0	4	0
5	306	-2,8	9	1	6	16	6	5	1	3	1	1	6	4
6	216	2,6	2	0	4	7	5	7	3	2	0	3	1	3
7	252	1,2	6	2	2	11	7	4	0	0	0	2	0	0
8	234	1,4	4	0	0	11	6	2	0	4	0	0	0	2
9	261	-2,1	7	0	1	19	7	7	0	0	1	2	0	0
10	225	0	5	0	1	12	3	7	0	1	1	3	3	4
11	225	0,5	4	0	1	8	9	10	0	5	2	1	2	0
12	252	-1	6	0	4	17	7	4	0	2	0	3	5	1
13	252	2,2	4	1	3	9	7	5	0	0	0	0	1	0
14	270	-1,8	5	0	3	15	5	6	0	6	0	2	3	2
15	234	1,3	4	0	4	10	4	7	0	0	0	1	1	0
16	288	-2	6	3	0	14	8	4	0	4	1	1	3	1
17	261	-1,7	5	0	5	12	8	8	1	8	0	1	2	1
18	270	-2,4	8	2	3	18	6	5	0	3	0	1	7	0
19	216	1,8	3	1	3	9	9	10	0	0	0	3	2	2
20	306	-2	7	0	2	15	6	3	0	5	3	4	6	3

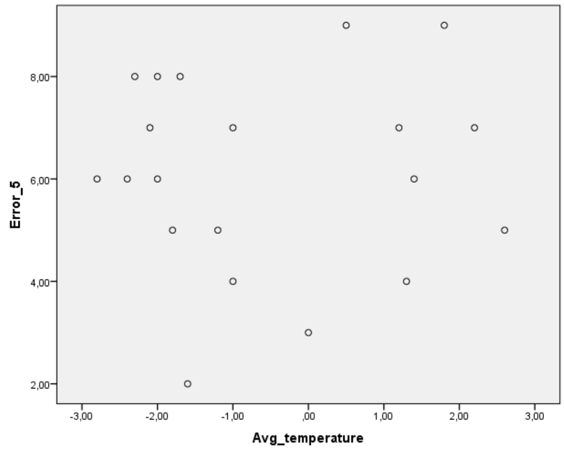
APPENDIX B

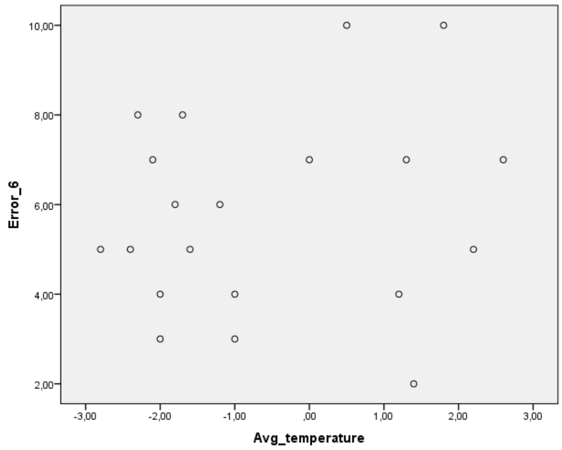

Error_1
Avg_temperature

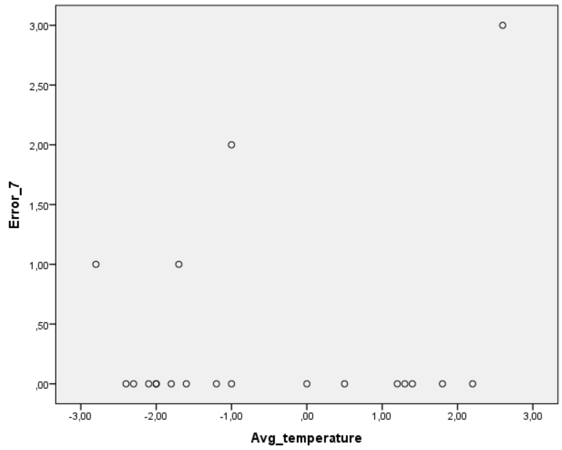

Error_2
Avg_temperature

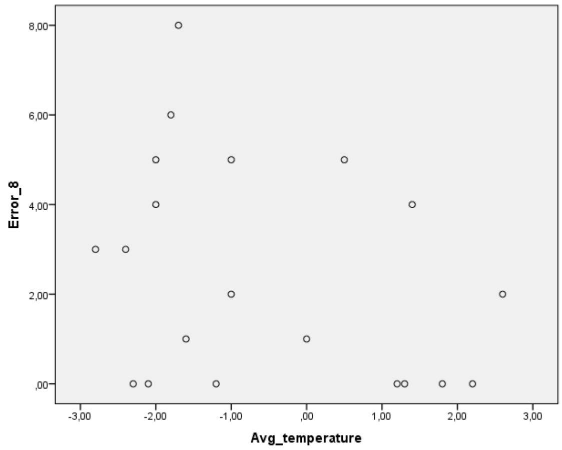

Error_3
Avg_temperature

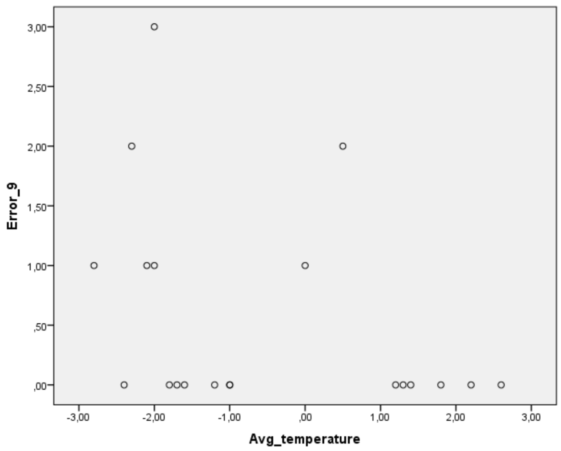

Error_4
Avg_temperature

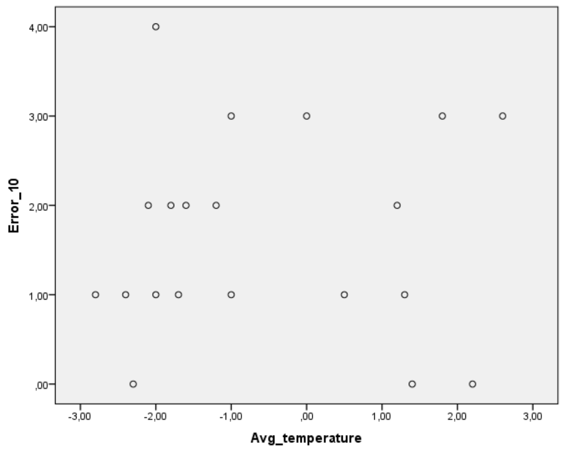

Error_5
Avg_temperature

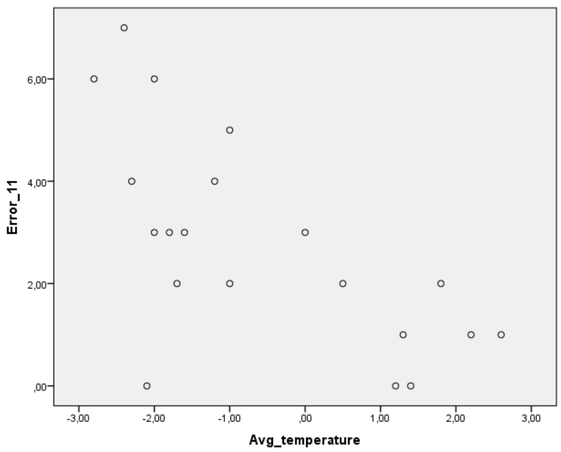

Error_6
Avg_temperature

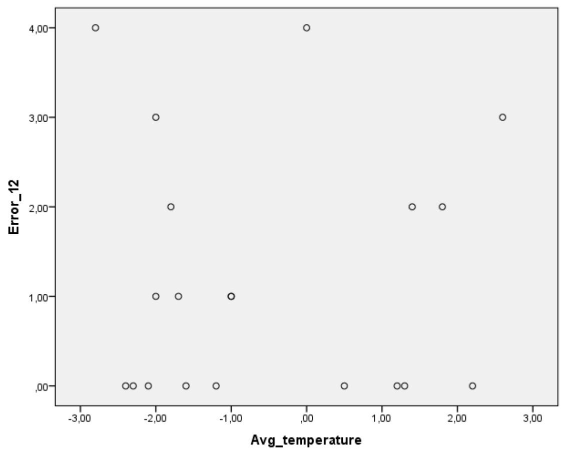

Error_7
3,00
2,50
2,00
1,50
1,00
,50
,00
-3,00 -2,00 -1,00 ,00 1,00 2,00 3,00
Avg_temperature


Error_8
8,00
6,00
4,00
2,00
,00
-3,00 -2,00 -1,00 ,00 1,00 2,00 3,00
Avg_temperature


Error_9
3,00
2,50
2,00
1,50
1,00
,50
,00
-3,00 -2,00 -1,00 ,00 1,00 2,00 3,00
Avg_temperature


Error_10
4,00
3,00
2,00
1,00
,00
-3,00 -2,00 -1,00 ,00 1,00 2,00 3,00
Avg_temperature


Error_11
6,00
4,00
2,00
,00
-3,00 -2,00 -1,00 ,00 1,00 2,00 3,00
Avg_temperature


Error_12
4,00
3,00
2,00
1,00
,00
-3,00 -2,00 -1,00 ,00 1,00 2,00 3,00
Avg_temperature