# Improving Logistics Efficiency

Evaluating the Potential of Slip Sheet in a Loose-Loaded Containerized Goods Flow

Master's thesis in the Master Program Supply Chain Management

LINNÉA JOSEFSSON
TOVE MANNHEIMER

DEPARTMENT OF TECHNOLOGY MANAGEMENT AND ECONOMICS
DIVISON OF SUPPLY AND OPERATIONS MANAGEMENT

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2020
www.chalmers.se
Report No. E2020:017

REPORT NO. E 2020:017

# Improving Logistics Efficiency

## Evaluating the Potential of Slip Sheet in a Loose-Loaded Containerized Goods Flow

LINNÉA JOSEFSSON
TOVE MANNHEIMER

Department of Technology Management and Economics
Division of Supply and Operations Management
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2020

Improving Logistics Efficiency
Evaluating the Potential of Slip Sheet in a Loose-Loaded Containerized Goods Flow
LINNÉA JOSEFSSON
TOVE MANNHEIMER



Report no. E2020:017
Department of Technology Management and Economics
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000

Gothenburg, Sweden 2020

Improving Logistics Efficiency
Evaluating the Potential of Slip Sheet in a Loose-Loaded Containerized Goods Flow

LINNÉA JOSEFSSON
TOVE MANNHEIMER

Department of Technology Management and Economics
Chalmers University of Technology

ABSTRACT
Efficient logistics and materials handling are essential to stay competitive. The purpose of this master thesis is to identify the potential of implementing slip sheet for materials handling in the loose-loaded containerized goods flow at a large actor in the Swedish grocery market. The benefit of the technology is that it enables rapid materials handling with a forklift, similar to handling palletized goods. Additionally, the sheet occupies less space than a pallet, enabling better space utilization in the container.

A mapping of the current logistics operations was performed to understand the context where slip sheet would be implemented. The thesis continues by evaluating the potential of slip sheet from multiple perspectives, such as how the contextual factors affect the suitability of the technology. An evaluation of the cost savings, additional incurred costs, as well as the required investments to implement the technology in the existing operations further provides insight into the financial implications of slip sheet. In addition to the financial analysis, a market analysis was performed to understand the suppliers' readiness in case of a conversion. Additional effects, such as opportunities and risks related to the slip sheet technology are also brought up and discussed. These factors include, but are not limited to; the possibilities of less damaged goods, reduced cost for container rentals, changes in the environmental impact, and the potential simplification of warehouse operations planning.

The results show that the potential of slip sheet is non-existent. Items that are large and bulky are not suitable to be loaded on slip sheet at all. For the uniform goods, the load factor deterioration results in a significant increase in shipping costs, that outweigh the savings in materials handling. The recommendation is to not utilize slip sheet for any of the containerized flows of the observed actor. A discussion about potential scenarios when the technology could become attractive is held. It is concluded that a significant change in the underlying factors is required to make slip sheet an interesting option.
.

Keywords: Slip sheet, load factor, materials handling, receiving operations, warehousing, unit loads, pallet, container.

ACKNOLEDGEMENTS
We would like to direct a thank you to Lars Medbo, Associate professor at the Department of Supply and Operations Management at Chalmers University of Technology, for valuable support and guidance during the course of the project.

We would also like to extend a thank you to the company representatives at ICA, that have been very helpful in supporting us throughout the project. A special thank you to Joacim Sjödahl, our supervisor at ICA, who has put much time and effort into supervising the thesis project and assisted us in getting hold of the right data and connecting us with the right people.

# Table of Contents

# List of Figures



# List of Tables

## Terminology

| | |
|---|---|
| **FMCG** | Fast Moving Consumer Goods. Items bought by consumers in large volumes at a low price. The FMCG are typically consumed at a fast rate and includes items such as beverages, processed foods, fresh foods, prepared meals, cosmetics and medicine. |
| **Loose-loaded** | A method used to fill containers. The distribution boxes are placed directly into the container without being formed into unit loads. As such it is possible to achieve a high load factor, as the entire container volume is addressable to be filled. |
| **Dry goods** | A segment of FMCG goods that is sometimes referred to as pantry goods. Includes canned foods, dried fruits, confectionery, beverages and detergents. |
| **Non food goods** | A segment of FMCG goods that includes kitchenware, clothing, books, gardening appliances and consumer electronics. |
| **Distribution box** | A box containing several consumer packages. |
| **TEU** | Twenty-foot Equivalent Unit. One TEU is a volume that corresponds to one 20-foot container. A 40-foot container corresponds to two TEUs. |
| **FCL** | Full Container Load. A fully loaded container shipped by ocean freight directly from the supplier to the customer. |
| **LCL** | Less than Container Load. Containers shipped by ocean freight where the cargo does not utilize the container's full capacity. |
| **Harbor Cargo** | External logistics provider. |
| **Big Bolts** | Actor in the manufacturing and construction materials industry. |
| **Global Furniture** | Actor in the furniture industry. |
| **Home Decor** | Actor in the homeware industry. |

# 1 Introduction

The introduction to the thesis is divided into background, purpose, problem analysis, and outline. First, the background section gives a brief introduction to ICA and to the problem the project aims to resolve. Second, the purpose of the project is described and discussed, followed by a description of the scope of the thesis. Third, the problem analysis results in the research questions being formulated. Lastly, an outline for the thesis is presented to support the reader in understanding the material.

For the purpose of not disclosing sensitive business material, the company names have been changed to fictitious ones. Further, the data in the report have been anonymized by adjusting the numbers or exclusively showing relations between them. Detailed calculations are not either included, removing the possibility to derive classified information from the results.

## 1.1 Background

ICA Sverige AB, further denominated ICA, is the largest actor in the Swedish FMCG market (ICA Gruppen, n.d.). ICA has about 1 300 grocery stores in Sweden and a market share of about 36%. The stores are operated and owned by individual storekeepers that can, on a voluntary basis, utilize services provided by the central ICA organization. ICA performs centralized activities within purchasing, logistics, marketing, and IT (ICA Gruppen, n.d.). The consolidation of activities results in economies of scale and a stronger purchasing power towards the suppliers than if each store would purchase separately. As a result, ICA's offer to the storekeepers is attractive compared to alternative suppliers, as expressed by Bergström and Sjödahl (personal communication, January 28, 2020).

The stores are divided into four segments ranging in descending order from the large supermarkets called ICA Maxi to ICA Kvantum to the medium size ICA Supermarket and the smaller convenience stores ICA Nära. Maxi and Kvantum have a focus on assortment and price, while Supermarket and Nära focus on accessibility and service. The stores are replenished on average five times per week.

In addition to groceries, ICA has a division called ICA Special, which procures and markets non food items, such as clothing and kitchenware (ICA Gruppen, n.d.). This segment of the assortment is referred to as Non food. As explained by Bergström and Sjödahl (personal communication, January 28, 2020), there are in total six main segments of items in the assortment; Dry goods, Fruit & Vegetables, Fresh, Frozen, Non food, and Flowers. Dry goods are sometimes referred to as pantry goods and includes all preserves, canned foods, flours and other food items that do not require certain temperature zones, contrary to the fresh and frozen segments.

The operations at ICA are separated according to function as described by Bergström and Sjödahl (personal communication, January 28, 2020). ICA Logistik is the department responsible for coordinating and managing all strategic, tactical, and operational logistics within the company. The logistics activities differ from most other companies as the different goods must be handled in different temperature zones, and a large share of the goods is perishable and require short lead times. This results in a very complex supply chain with a high variety of transport modes being used, as well as a network of central warehouses, distribution centers and terminals to fulfill the logistics requirements (E. Bergström & J. Sjödahl, personal communication, January 28, 2020).

In the 1950s ICA had about 68 warehouses and 11 000 stores (E. Bergström & J. Sjödahl, personal communication, January 28, 2020). Since then, ICA has consolidated the physical structure to five main warehouses and about 1 300 stores. The warehouses are located in Helsingborg, Västerås, Kungälv, Kallhäll (Stockholm) and Borlänge. There are two different kinds of warehouse functions in the structure; central warehouses and distribution units.

The distribution units are responsible for receiving and further distribute goods to the ICA stores located within their assigned geographical area. The distribution units keep high runners in the inventory to be able to supply the stores efficiently. In addition to the high runners, there are a lot of goods with a lower turnover rate which cannot be kept at the distribution units because of limited capacity. These low runner goods are instead stored at the central warehouses. When demand arises, the goods are sent from the central warehouses via the distribution units to the stores. In addition to the central warehouses and distribution units, there are smaller distribution points without storage and external warehouses used in the distribution system (E. Bergström & J. Sjödahl, personal communication, January 28, 2020). One of the external logistics service providers that ICA utilizes is Harbor Cargo in Gothenburg. Harbor Cargo runs the operations of the warehouse that handles the flow of Dry goods that arrive at the port of Gothenburg. The Non food goods are shipped to Gothenburg and then forwarded to one of ICA's internal warehouses. At Harbor Cargo, the goods that arrive are put in intermediate storage and are then forwarded to one of ICA's internal warehouses before it is distributed to the stores. Harbor Cargo has capabilities to receive both loose-loaded containers and goods loaded on pallets and slip sheets, further explained below.

A large share of the Dry goods and Non food items arrive at the port in containers that have been shipped from Asia by boat. After arriving at the port, the containers are further transported to the warehouses by truck (E. Bergström & J. Sjödahl, personal communication, January 28, 2020). The containers have a long lead time of several weeks and as a result, there is a wish to maximize the load factor of each container. To achieve a high load factor, the suppliers stack the goods in boxes in the container without pallets, often referred to as loose-loading. As such they avoid using valuable container space for pallets. However, loose-loading results in high costs for materials handling, as the goods must be loaded and unloaded from the container manually. In the process of unloading, the goods are stacked on pallets and stretch wrapped for further transportation.

An alternative to loose-loading is to use slip sheet. Slip sheet is a technology where a sturdy carton board or plastic sheet is used in a similar manner as a pallet. The slip sheet has the same dimensions as a pallet but is only a few millimeters high. The goods are stacked and stretch wrapped at the sending point just as if using a regular pallet. The slip sheet can then be handled by a forklift with a special attachment, illustrated in Figure 1 below. The forklift utilizes a push/pull attachment to slide the slip sheet on and off the forklift platens. The benefit of the technology is that it enables rapid materials handling with a forklift, similar to handling palletized goods. However, the sheet does not occupy much space, resulting in better space utilization in the container. When the containers are unloaded at the receiving point, the slip sheets can be transferred onto a regular pallet by using a certain attachment on the forklift. The technology needed to use slip sheet is currently implemented in the external warehouse in Gothenburg, Harbor Cargo. However, ICA's internal warehouses have no capabilities to receive goods loaded on slip sheets.


*Figure 1. An illustration of the slip sheet technology. Images retrieved from Sopack (n.d.-a).*

The master thesis project was initiated by ICA to evaluate the potential business impact of implementing slip sheet in the receiving operations of two internal warehouses, Warehouse 1 and Warehouse 2, and extending the use of slip sheet at the external warehouse Harbor Cargo. The current insight into the shipping process is rather limited, and decisions are commonly made based on a relationship with the supplier rather than by economically evaluating the situation.

The project was executed as a master thesis by Linnéa Josefsson and Tove Mannheimer, who are both students of the Supply Chain Management master program at Chalmers University of Technology. The thesis was supervised by Lars Medbo, Associate professor at the Department of Supply and Operations planning. Joacim Sjödahl was the project supervisor at ICA and assisted in finding the right people to contact, retrieving internal data from ICA, supporting the project, and scheduling visits at the warehouses.

The existing research on the implications of using slip sheet is very limited. The technology was first invented in the 1940s and received relatively widespread attention in the late 1990s (Johnson, 1980; Eltete, n.d.). Despite the long history, little research has been made regarding the benefits and drawbacks of slip sheet. As such, the addition to academia in investigating and evaluating the technology compared to loose-loading is thought to contribute to valuable insights.

The subject of slip sheet is related to both resource utilization and handling efficiency, which are important topics in today's logistics agenda. Since the introduction of the shipping container in the mid-1950s, the majority of general cargo has been containerized (Rodrigue, 2020). Containerization and globalization are interrelated, and containerization is thought to have contributed significantly to growth in international trade. The widespread containerization in global supply chains is thought to make the findings of the research interesting to a wider audience.

## 1.2 Purpose

The purpose of this master thesis is to identify the impact of implementing slip sheet for materials handling in the loose-loaded containerized goods flow at ICA. The thesis aims to evaluate the potential by considering multiple perspectives of the technology, such as the contextual factors where the technology would be implemented. An evaluation of the cost savings, additional incurred costs, as well as the required investments to implement the technology in the existing operations will further provide insight into the financial impact of slip sheet. In addition to the financial impact, a market analysis is performed to understand how widespread the technology is and to understand the suppliers' readiness in case of a conversion. Additional effects, such as opportunities and risks related to the slip sheet technology are also brought up and discussed. These factors include, but are not limited to; the possibilities of less damaged goods, improved working conditions and ergonomics, changes in the environmental impact, and the potential simplification of warehouse operations planning due to reduced variation in the unloading processes.

The scope of the thesis is limited to the two internal warehouses Warehouse 1 and Warehouse 2, as well as the external warehouse Harbor Cargo in Gothenburg. To achieve a broader empirical foundation for the analysis, additional input from actors in other industries is used to complement the data. The goods segments observed at ICA are Non food and Dry goods. Only goods that are currently arriving in loose-loaded containers are included in the scope of the financial analysis in the project. All goods arriving on pallets, and all unit loads other than containers are consequently excluded from the scope. This since ICA expects slip sheets to initially have the highest potential when implemented in the loose-loaded containerized flows.

The effects of slip sheet in the unloading operations at ICA are investigated both quantitatively and qualitatively. A potential implementation of slip sheet is dependent on the suppliers' logistics operations and working practices. Since the required investments and changes in the operations at the suppliers may vary depending on their current capabilities, a quantitative assessment of the financial impact at the supplier side is considered to be outside the scope of this project. However, evaluating the supplier's willingness to convert to the technology more qualitatively is integral for the research. The investigation is mainly performed by interviewing strategic purchasers and surveying the suppliers, giving an indication of how attractive slip sheet is to the suppliers.

The project aims to provide ICA with recommendations on the topic of slip sheet at a practical level. The financial analysis in combination with additional risks and barriers for implementation will be the foundation for the recommendation. In addition, reasoning about the transferability of the results to other actors and industries will be provided. The ambition is that the research will give insights about logistics efficiency and unit loads for a wider audience.

## 1.3 Problem Analysis

The aim of the project is translated into research questions, which guide the authors on how to approach and solve the problem. In order to know how to potentially improve the logistics operations at ICA, it is crucial to have a good understanding of the current state. As such, the first research question is:

1. *What is the current flow of loose-loaded containerized goods to Sweden in terms of volumes, suppliers, type of goods, and receiving warehouses?*

When a common view on the current state is established, the potential of a transition to slip sheet must be identified. This is done by examining several factors jointly to give a comprehensive recommendation about the impact of the technology. First, the context where slip sheet will be applied is analyzed. Second, the supplier base will be investigated in order to understand if it is possible to realize the potential. Third, the related required investments will be identified. Finally, the financial impact will be evaluated by identifying the direct savings and additional costs incurred of a potential transition. All factors will be combined to give a holistic perspective and recommendation about slip sheet. The second research question is as follows:

2. *What are the immediate effects and the financial potential of implementing slip sheet at ICA's central warehouses, Warehouse 1 and Warehouse 2, and/or extending the use of slip sheet at Harbor Cargo in Gothenburg?*

The final part of the purpose concerns important topics related to an eventual implementation. In addition to the direct savings and costs, it is important to understand the second-round effects of implementing slip sheet, which are more difficult to quantify. These are for example changes in the environmental impact or planning of resources in receiving operations. The third and final question is discussed and evaluated to give a more comprehensive recommendation in combination with the previous results. The research question is as follows:

3. *What are the additional effects of implementing slip sheet?*

## 1.4 Outline

The report starts by introducing the academic foundation, also referred to as the theoretical framework, that covers essential topics to understand the subject of the thesis. Following the theoretical framework is a presentation of the empirical findings. The Empirical Findings chapter will mainly consist of a current state map of the containerized flows at ICA and the findings from external actors that have experience from slip sheet. In the Analysis chapter, the potential of slip sheet will be evaluated for the two goods segments. The analysis is split into five segments, starting with an analysis of the preconditions provided by the context where the technology would be set. The contextual analysis is followed by a supplier base analysis, which will provide insight into the availability of the technology. Following the supplier base evaluation is the investment analysis that presents the required equipment and the associated costs. After that, the impact that slip sheet would have on the annual operating costs is calculated and analyzed. The analysis is finished by presenting findings of additional effects related to the implementation of slip sheet. The findings from the analysis chapter will then be further elaborated and debated in the Discussion chapter. Here the authors will argue for and against alternative solutions and present benefits and drawbacks of the options. The final recommendation to ICA and key takeaways will then be presented in the Conclusion chapter.

# 2 Theoretical Framework

Below follows a presentation of the findings from the literature study. The theoretical framework is used as a frame of reference to evaluate the empirical findings and analyze them in relation to the research questions. The theoretical framework begins with a description of warehouse operations and more specifically the characteristics of receiving operations. Knowledge within this area is valuable for understanding the potential impact of a slip sheet implementation in ICA's supply chain. The chapter then continues to describe the concept of unit loads, different types of unit loads, and their implications on the receiving operations. Insights in this field of study are important to understand the fundamentals of slip sheet and how a transition to this technology will affect the product flows. The load factor framework is then investigated and put in relation to the scope of the project, broadening the understanding of slip sheet implications even further. Additionally, the main features of payback period methods for investment analysis are presented. The investment theory is used for evaluating the potential and financial implications of slip sheet at ICA. Finally, theory about making a sensitivity analysis is described and later used for validity and risk assessment of the recommendations.

## 2.1 Warehouse Operations

The basic functions of a warehouse are; receiving, storage, order picking, and shipping (Gu, Goetschalckx, & McGinnis, 2007). The planning of warehouse operations is dependent on contextual factors and available models. Due to market competition, it is essential to continuously improve the performance in the warehouse operations. New management practices such as just-in-time or demands for shorter lead times may further strain the warehouse systems. However, new technologies such as automation and improved software systems provide opportunities to improve existing practices (Gu et al., 2007).

The time required for receiving operations is dependent on several factors. The time needed for the unloading of a container is, for example, dependent on the container size, the number of consignments in the container, and whether the consignments can be handled mechanically or manually. A major difficulty in planning warehouse operations is to allocate resources, such as equipment, staff, and space to the different activities, and to coordinate the activities to achieve the system requirements regarding lead time, service level and capacity while minimizing the total cost (Gu et al., 2007). Having too much staff will result in high labor costs and reduced productivity (Tompkins, 1994). Having too little staff can lead to quality issues, employee burnouts, and low attainment, which leads to higher costs in the long run. The flexibility in the staffing of the warehouse is an important aspect of the matter, where temporary staff can be a tool to increase the ability to adjust the capacity rapidly. Other aspects of flexibility include the competence of the staff and the availability of the equipment. To conclude, it is important to plan the employee requirements well to minimize costs.

All tasks involving human labor has an inherent variation in efficiency and productivity. A close connection exists between the variation of a process, the throughput time and the resource efficiency (Modig & Åhström, 2015). There is an exponential connection between the throughput time and the resource utilization, that extends into infinity as the utilization approaches 100%. The variation of the process affects how rapidly the curve grows, which can be seen in Figure 2 and is referred to as Kingman's equation. The equation shows the relation between the resource utilization and the throughput time in a process. The two curves illustrate how high and low variation in the process affects the performance. Productivity can be increased by simplifying processes or improving the method used (Tompkins, 1994). The variation of a process can be studied and reduced using the philosophy of Six Sigma (Murman, McManus, Weigel, & Madsen, 2012). Standardization of tasks can also be used as a tool to reduce the variation, which is common in the Lean philosophy of 5S (Goldsby & Martichenko, 2005). Standardization implies that all steps of the process, the time required for all steps, and the expected output should be known. By standardizing operations, it is possible to build a foundation for continuous improvement. Standardization and improvement can, in turn, reduce the inherent variation of the process and make it more stable (MĺkvA, Prajová, Yakimovich, Korshunov, & Tyurin, 2016).

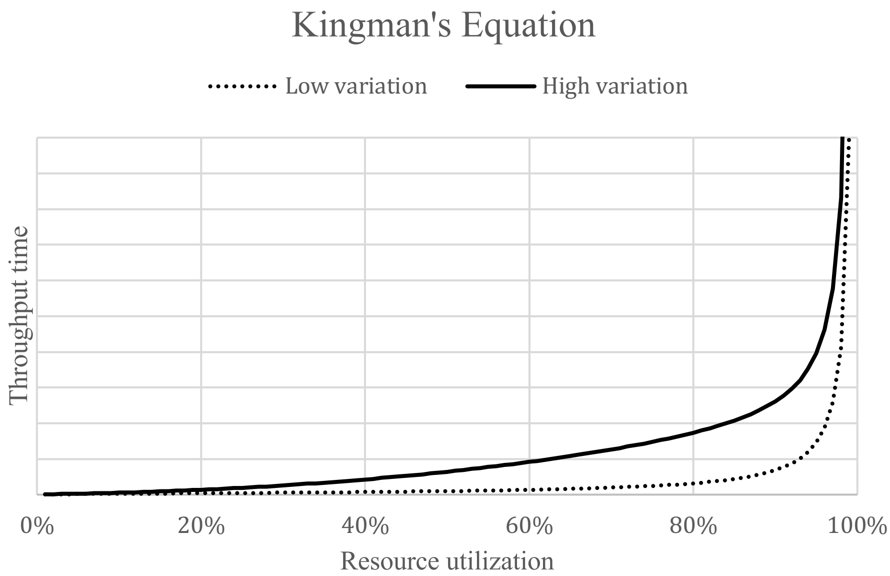


*Figure 2. Kingman's Equation. Based on Modig and Åhlström (2015).*

Another important aspect of human labor is to consider the restrictions provided by the authorities. The Swedish Work Environment Authority restricts all manual lifts exceeding 25 kilograms (Arbetsmiljöverket, 2020). Lifts over 15 kilograms should not be part of the daily tasks, as it increases the risk of exhausting the spine and the back muscles. The Swedish Work Environment Authority suggests utilizing equipment to simplify the lifting, or to make organizational changes that reduce the strain on the operator, such as rotating the work stations between the operators.

The resource allocation decisions specific to the receiving operations are dependent on the level of knowledge about the incoming shipments (Gu et al., 2007). The knowledge can vary from no prior knowledge about the content to perfect knowledge about the arrival time and the content of the arriving shipment. If no prior knowledge is available, the assignment of resources is difficult to perform. The higher the uncertainty, the more excess capacity must be planned to manage the risk of being understaffed (Wruck, Vis, & Boter, 2017). Wruck et al. (2017) suggest considering both the cost of the resource and the level of uncertainty in the process when deciding how to allocate the resources. The most common situation is a partial statistical knowledge about the content of the arriving shipment. Expected volume and item numbers are known, but the loading of the goods may be unknown. The level of uncertainty regarding the content of shipments varies across industries. In some industries, such as the automotive industry, it is common to have closed loops of returnable packaging, which ensures good knowledge about the loading method used for the shipping (Pålsson, Finnsgård, & Wänström, 2013). The higher the level of information available about the content of the shipment, the better scheduling is possible (Gu et al., 2007).

If the incoming unit loads are different from the unit loads used for internal storage and continued handling, the loads must be repacked (van den Berg & Zijm, 1999). This could be the case when the supplier has loaded the goods on a different sized pallet or slip sheet than what the warehouse is built for. This is also the case when the goods arrive loose-loaded and must be stacked on pallets for continued handling. Besides being physically compatible with the continued flow, there may be additional reasons for repacking the goods, such as customer requirements on consignment size.

## 2.2 Unit Loads

In this part of the theoretical framework, the concept of unit loads will be presented in more general terms. Three different kinds of unit loads and their main features will be described in more detail; containers, pallets, and slip sheets. The chosen unit loads can be seen in Figure 3, from left to right; container, pallet, and slip sheet. The understanding of their functionality is valuable knowledge in assessing how a potential implementation of slip sheet could affect ICA's operations.

*Figure 3. Pictures showing units loads. Images, from left to right, retrieved from TFH (n.d.), Kronus (n.d.), and Corpal (n.d).*

A unit load is one or several items arranged so that they can be handled as a single object that is too large for manual handling (Daboub, Trevino, Liao, & Wang, 1989). According to Spencer and Ebeling (2011), handling unitized loads is economically a better alternative compared to handling separate loads manually. Lumsden (2007) has formulated a unit load principle stating that several unit loads should be consolidated into one larger unit load whenever possible. The principle is formed from a transport perspective. The unit load should be formed as early as possible, ideally at the supplier, and broken as late as possible, preferably at the final customer. Ackerman (1990) presents three similar principles that support the formation of unit loads in transport. Firstly, unit load should be as large as can be practically handled. Secondly, the material should be handled as few times as possible. Third and lastly, mechanical equipment should be preferred over manual labor whenever possible. The aim to form large unit loads is from a transport perspective, as it enables good resource utilization in the transport. For other purposes, different sizes of unit loads may be preferred. This is, for example, the case in Lean logistics, where an order size adapted to actual demand is considered ideal (Baudin, 2005).

Lumsden (2007) highlights the importance that the unit loads should be easy to handle with the equipment that is available in the system. At any place where handling must occur, the right equipment must exist. As such, it is important to consider which investment requirements that follow the implementation of the new technology and put in relation to the value of mechanizing the operation. The time horizon of the investment must also be considered, as it may take time before the payback of the initial investment is reached. In addition to being able to handle it with some type of handling equipment, the unit load must be stable enough to be stacked with other unit loads of different weights (Lumsden, 2007). The logic behind the formation of unit loads is that if each item requires separate handling, the transfer activities between the different means of transportation, such as receiving and shipping operations, become too time-consuming and therefore too expensive. By reducing the handling costs, the total transport cost can be reduced (Lumsden, 2007). Savings in the warehouse operations may also be derived from the shortened handling time and improved utilization of resources, that leads to less external costs, such as container rental costs. Additional savings can be derived from reduced damage costs and lower employee turnover rates.

The context where the unit load will be handled is important to consider when the unit load is designed. Some important aspects to consider are space, weight, product flow, transportation, storage, handling, and packaging costs (Daboub et al., 1989). The shape and dimensions of the packaging determine and limit the load utilization efficiency that can be achieved (Pålsson et al., 2013). The infrastructure surrounding transport is often very expensive or impossible to change, which is why consideration must be taken to any constraints it poses. Generally, the formation of unit loads enables the handling to be mechanized or automated to a larger extent, resulting in fewer man-hours. Increasing mechanization or automation reduces the time required for the terminal operations, leading to less waiting time for terminal vehicles and higher resource utilization. Increasing the degree of mechanization of the operations typically requires investments in handling equipment (Lumsden, 2007). The equipment can be related to transportation or terminal handling. The investment often consists of the cost of the handling equipment, such as forklifts, slip sheets, pallets, or containers. In addition to that, handling of empty return loads and increased administration costs must also be considered. Kay (2012) argues that materials handling operations should be mechanized or automated if viable, to improve the operating efficiency, predictability, and consistency, decrease the cost of operations, and eliminate repetitive and hazardous manual labor. Once again, the time aspect and return on the investment in equipment must be considered. McCrea (2019) further states that there is a focus on automation, robotics, and artificial intelligence (AI) in the future of logistics. IFCO Systems (2017) describes how any automated warehousing systems require the goods to be stored on pallets or to be unitized in some other way, such as in plastic containers or boxes. The development trend of increasing automation makes it important to consider the compatibility with automation while designing the unit load.

The cost savings of mechanization and automation are mainly derived from a decrease in manpower hours per handled unit. The desire to decrease man-hours becomes more prominent as the salary levels in many countries are steadily increasing, making mechanized or automated solutions increasingly attractive. The increase in real salary in the Asia Pacific region is nearly thrice the European average development (Human Resources Online, 2019). Additional costs of automation may surface if there are issues with for example uptime or maintenance. Following the unit load principle proposed by Lumsden (2007), unit loads should be created if the realized cost savings are larger than the additional costs.

Pallets, slip sheets, containers, or other alternative unit loads are used to build the foundation of the unit load (Lumsden, 2007). Forklifts, pallet jacks, or tugger trains are then used to transport the unit loads at the receiving and shipping areas and within the warehouse. Different transport modes such as trucks, ships, and trains are used to carry the unit loads and transport them between nodes in the transport system (Lumsden, 2007).

In this report, a unit load will be defined as a full pallet stack of packages containing products, also referred to as distribution boxes. A container filled with unit loads will also be referred to as a unit load. In Figure 4, the definitions are visualized using images from the software Cape Pack. From left to right, the images show a distribution box, a pallet-sized unit load of distribution boxes on slip sheet, and finally a 20-foot container loaded with unit loads on slip sheet. Both the slip sheet with goods and the loaded container will be referred to as types of unit loads in the report. Below follow the descriptions of containers, pallets, and slip sheets, and their distinct features when they are used to form unit loads.

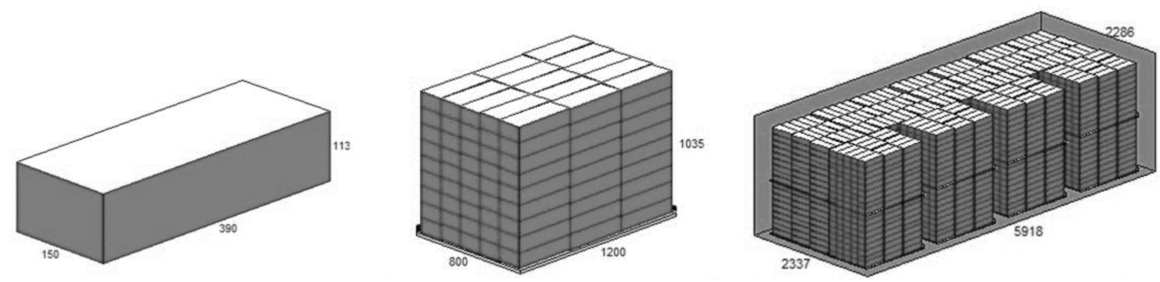

*Figure 4. Simulation of unit loads in Cape Pack.*

### 2.2.1 Containers

The container was invented in 1956 and has since developed to become an integral part of the supply chains of today (Cudahy, 2006). The main function of a container is to facilitate efficient handling in the supply chain and protect the goods during transport (Lumsden, 2007). Since there may be modal shifts throughout the chain, it is required that the container can be handled by a variety of transport modes and handling equipment. The size of containers has been standardized in order to enable efficient exchange across the chain. An ISO container is most commonly 20 or 40 feet long. The capacity unit in transport is consequently often measured in TEU's, Twenty-foot Equivalent Units (Lumsden, 2007).

The container is loaded with goods and sealed before being shipped to the recipient. The size of the ISO container is not well-matched with the size of the European pallet (EUR-pallet). This results in a poor load factor when this type of unit load is loaded in the container (Lumsden, 2007). To attain higher load factors, Lumsden (2007) mentions the option to manually fill the container, so-called loose-loading. The drawbacks of the manual method are high costs for loading and unloading the container. According to McDonald (2016), unloading a loose-loaded container takes two to six times longer than a palletized one.

Achieving a high load factor in the containers is essential for efficient operations in the supply chain (Bortfeldt & Wäscher, 2013; Jamrus & Chien, 2016). If a high load factor is not achieved, shipping costs are increased as additional containers must be shipped. Low load factors may also result in lower customer satisfaction as the goods may not arrive according to the agreed delivery scheme and deadlines. The demand volumes in the supply chain affect the load factor that can be achieved in the containers. If the order volume exceeds the capacity of the container, the goods must be split into several containers, and the customer may not receive the complete delivery at once. If the customer order volume is less than the container load, the resulting load factor will be poor unless some consolidation can be done, which in turn may prolong the delivery time. Jamrus and Chien (2016) describes how it is a challenge to maximize the utilization of containers. A container where the volume is not fully utilized is called less-than-container-load (LCL), and a container filled to its maximum is referred to as full-container-load (FCL). Several LCL shipments can be consolidated into one FCL shipment in order increase the supply chain efficiency (Jamrus & Chien, 2016). To conclude, container loading is a central theme in the field of logistics research. The container loading problem is further complicated by several restrictions on the system such as maximum weight, volume, and stacking constraints (Bortfeldt & Wäscher, 2013).

Rodrigue (2020) describes how the cost for transporting containers is affected by several factors, among them the transaction costs and shipment costs. Shipment costs include activities such as preparing the goods for transportation and loading it into the container. Major influencers of the transportation cost are transport mode, time and distance, as well as the actual demand or volume shipped. The time factor consists of for example transportation time and frequency. The type of product being shipped can affect the transport price if, for example, it is flammable or requires certain caution. The product itself does not influence the price if it is shipped in a regular container, instead the number of containers is of great concern, as well as how they are loaded and unloaded. The number of containers will be dependent on the customer demand. One way to lower the transport costs is to achieve economies of scale in the transport units by sending larger quantities.

### 2.2.2 Pallets

Pallets are the most popular unit load system, primarily because of the low cost of pallets and the ease for an operator to handle them (Spencer & Ebeling, 2011). Pallets are rigid platforms made out of different materials that can support a wide range of goods during handling, shipment, and storage (Laundrie, 1986). Wooden pallets are the most common type, but plastics are gaining in popularity (Kay, 2012). Pallets enable the formation of unit loads for easier transportation, but it can be hard to find the optimal loading patterns of the boxes. A stack pattern is a drawing that illustrates how the goods should be placed in each layer and the number of layers that can be stacked on top of each other to form the unit load. When loading items onto a pallet, it is easier if they are rectangular (Kay, 2012). The palletized unit load is often stretch wrapped to stabilize it further (White & Hammer, 2005). Sometimes a wooden pallet collar is used instead of stretch wrap (Leblanc, 2019).

The measures of a pallet vary in different parts of the world, six of them approved by the ISO standard system (iGPS, 2018). The EUR-pallet system is the most widely used pallet system in the world, especially in Europe and in in the grocery industry (Twede, Mollenkopf, & Guzman-Siller, 2007). The EUR-pallet have the measures 1200 * 800 * 144 millimeters (PAKi Logistics, n.d.). In Asia however, the most commonly used pallets have the dimensions 1100 * 1100 millimeters or 1200 * 1000 millimeters. Further, in North America, the dominating dimensions are 1016 * 1219 millimeters (iGPS, 2018). Many actors that utilize pallets have organized return loops or networks for empty pallets that enable reuse of the pallets. The return flow of a unit load is highlighted by Lumsden (2007) as an important factor to consider when selecting which unit load to use in a flow. Dealing with pallets of different dimensions is a challenge in many supply chains (Supply Chain Asia, 2018). The various pallets have been developed and adapted for different situations. For example, the EUR-pallet is adapted to fit in narrow doorways, and the North American pallet is better suited for utilizing the space in an ISO container (iGPS, 2018). As mentioned before, a major drawback with the EUR-pallet is the lack of compatibility with the ISO container dimensions. Loading a 40-foot ISO container with EUR-pallets eventuate a floor utilization of up to 85% (McDonald, 2016). When loading a 40-foot ISO container with the North American dimensions, it is possible to utilize the floor area up to 96% (Supply Chain Asia, 2018). The EUR-pallet is instead well compatible with the measures of a European semi-trailer (Access Logistics, n.d.).

An implication of the wooden pallet being the most common unit load system is that supply chains often optimize their boxes to fit on pallets. Since different regions optimize for different pallet dimensions it creates a challenge when trading worldwide (McDonald, 2016). Another result of the widespread use of pallets is that supply chains are designed for handling standardized pallets and therefore have the proper equipment for handling them (White & Hamner, 2005). Alternatives to pallets can be other techniques serving the same purpose of creating a unit load, one example is slip sheet (McDonald, 2016).

### 2.2.3 Slip Sheet

The slip sheet technology consists of two main components; a special forklift attachment and a slip sheet. There are different designs on the forklift attachment but the ability to handle a slip sheet load is the feature they have in common. The attachment is mounted on the front of a regular forklift, which is commonly available in warehouses (Laundrie, 1986). The slip sheets used in the system works as a replacement for regular pallets, but the big advantage is that it requires less space in the transport while still enabling transportation of goods as a unit load (Spencer & Ebeling, 2011). Compared to loading and unloading manually, a lot of costs can be saved by using the slip sheet technology (Bouma, 1980). A reason for the slow implementation of slip sheet in the industry, since its invention in the 1940s, is considered to be the costs associated with the equipment needed for handling the slip sheets (Bouma & Shaffer, 1982). The attachment investment is required at the supplier site for unloading, and at the receiving warehouse for unloading (Bouma & Shaffer, 1982). A warehouse receiving goods on slip sheet that does not have the right equipment cannot take part in the gains (Bouma, 1980). However, the use of slip sheet continues to grow within the material handling industry as a way to replace traditional pallets (Castetter, 2019).

Rollerforks and push/pull attachments are different types of forklift attachments that enable handling of the slip sheets. The push/pull attachment, to the left in Figure 5 below, can be easily mounted and removed from the forklift, which enables the truck to be used for other activities as well (B&B Attachments, 2017). Push/pull attachments enable fast loading and unloading and are built up by three components; facelift, gripper, and forks. When moving units loaded on a slip sheet, the gripper attaches to a protruding flap of the slip sheet and pulls the unit load onto the forks of the forklift by contracting the facelift (Sopack, n.d.-b). After pulling the load, it can be pushed off from the forks onto the floor, a pallet, or another stack of unit loads (Spencer & Ebeling, 2011). Using this kind of attachment is about 15% slower than using regular forks, and it requires properly trained operators in order not to damage the goods (Johnson, 1980). Since mounting the attachment to the forklift is a quick operation, the forklift can be used for both pallets and slip sheets without much time loss in the change between modes (B&B Attachments, 2017).

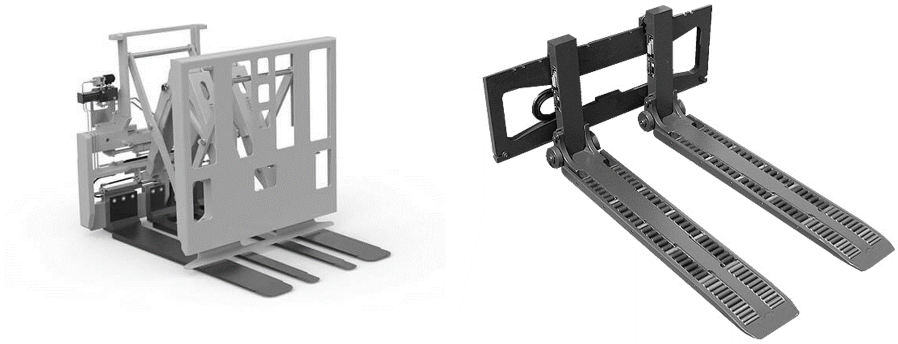

*Figure 5. Slip sheet forklift attachments. Images, from left to right, retrieved from Conger (n.d.) and Griptech (n.d.).*

Rollerforks was invented as an alternative to the push/pull attachment. Since the goods are often very heavy, a lot of friction arises on the platens of the attachment. The rollerforks have several wheels on the forks, reducing the friction when doing the pulling and pushing, which can be seen to the right in Figure 5 above. A drawback is that rollerforks can only be used for singled-stacked loads (Meijer Handling Solutions, n.d.-a). Rollerforks used in combination with a traditional push/pull attachment enables handling in multiple levels so that unit loads can be stacked on each other (Meijer Handling Solutions, n.d.-b).

The slip sheets vary in design and material. The sheet can be of different sizes and have one or several flaps on the sides. The material which the slip sheet is made out of is either corrugated paperboard, fiberboard, or plastic (Johnson, 1980). The main difference is the trade-off between durability and cost, where durability is considered in terms of how many push/pulls that can be handled and the resistance to humidity and cold temperatures. Paperboard being the least durable and cheapest one, plastic the most durable and most expensive one, and fiberboard being somewhere in between (Mulcahy, 1999). The slip sheet itself is not rigid enough to use in pallet rackings and it has to be supported by another platform, for example, a pallet (Johnson, 1980).

Compared to using pallets, the slip sheets require less space inside the container (Spencer & Ebeling, 2011). The space utilization with slip sheet can be expected to be around ten percent higher compared to using pallets (Bouma & Shaffer, 1982). The slip sheets are also cheaper than pallets. When using slip sheet, the center of gravity of the load is lowered compared to using a pallet. If there is a shift of the stacks during transport, the risk of the load leaving the unit load is lower since the load and slip sheet move together, resulting in less damaged goods (Johnson, 1980). The relative benefits of slip sheets compared to pallets are as such; the pallet must not occupy space in the container, the value of the pallet is not tied-up in the container during transport, and there are less damaged goods.

Comparing loose-loading and the use of slip sheet, an advantage is that slip sheet requires less labor for loading and unloading (Castetter, 2019). The increased efficiency in materials handling is clearly showed by Spencer and Ebeling (2011), who present some case examples where companies have implemented slip sheet and identified key success factors. For the tech company Apple several important factors were identified for a successful implementation; high-quality slip sheets, training of operators, committed top management, a dedicated team for implementation, and a lot of communication. A result from the implementation of slip sheet at Apple was 75% less labor in the unloading operations, compared to before when the products were loose-loaded. Unloading a loose-loaded container required six man-hours before, but with slip sheet the time was reduced to less than 30 minutes. Another case described by Spencer and Ebeling (2011) is implementation of slip sheet at Quaker State Oil. In this example it was possible to reduce the handling time from four man-hours of manual loading to less than 20 minutes per container. A third case description by Spencer and Ebeling (2011) was one where Home Depot decided to ship their products from the supplier to the warehouses on slip sheet. One factor that made this major shift possible was their negotiation power over the suppliers and the suppliers' willingness to continue to serve Home Depot. In an additional study, presented by Bouma (1980), costs are compared between loose-loaded operations and slip sheet operations. Based on loading and unloading a loose-loaded container with 1 320 distribution boxes or the same number of boxes on 20 slip sheets by a push/pull attachment, the labor costs were reduced by nearly 65%.

Not all products are suitable for transporting on slip sheets. The products should be homogenous and proportionate to be compatible with the use of slip sheet (Castetter, 2019). The products ought to be assembled in multiple layers, creating a unit load (Johnson, 1980). Choosing to implement slip sheet for products that are not appropriate can result in an unacceptable return on the needed investments (Castetter, 2019). Bulky products and products with large dimensions are examples of less appropriate products, since the need for creating a unit load is not as significant. Additionally, too heavy products are not either appropriate for transporting on slip sheet because of the risk of breaking the tab on the slip sheet (Johnson, 1980).

## 2.3 The Load Factor Framework

The load factor in transportation can be described as the efficiency in loading orders in available shipping capacity (Santén, 2016). It can be expressed as the ratio of required capacity and the available capacity, but can also be evaluated at more granular levels that gives a better comprehension. Santén (2016) proposes a formula where the load factor is divided into three indicators:

$$Load\ factor = Packaging\ efficiency * Loading\ efficiency * Booking\ efficiency$$

The packaging efficiency indicates the ability to efficiently load items into distribution packages, such as carton boxes. The loading efficiency indicates how well the distribution box can be stacked into unit loads. Depending on the number of levels of unit loads used in the system, this factor is dependent on several interfaces. If the distribution boxes are first stacked into pallet shaped unit loads, and then loaded into a container, the loading efficiency will depend both on the load factor of distribution boxes on the pallet, and the load factor of pallets in the container. Meanwhile, if the distribution boxes are loose-loaded directly into the container, the load factor is only dependent on the interface between the distribution box and container dimensions. The booking efficiency describes how well the shipper utilizes the capacity that has been made available. If the shipper books a full container load to be shipped but only fills it with half a container load, the booking efficiency will be 50%.

A high load factor is essential to reduce the total amount of traffic and in turn reduce the shipper's environmental impact (Santén, 2016). The shippers can change their logistic actions to affect the available and/or required capacity. Three logistics variables presented by Santén (2016) can affect the three load factor indicators. These are; Product characteristics, Order variation, and Lead time. In Figure 6, it is displayed which load factor indicator is affected by which logistics variable. From the figure it is possible to see that the product characteristics mainly affect the packaging efficiency and loading efficiency. The order variation and lead time affect the efficiency at all three levels.

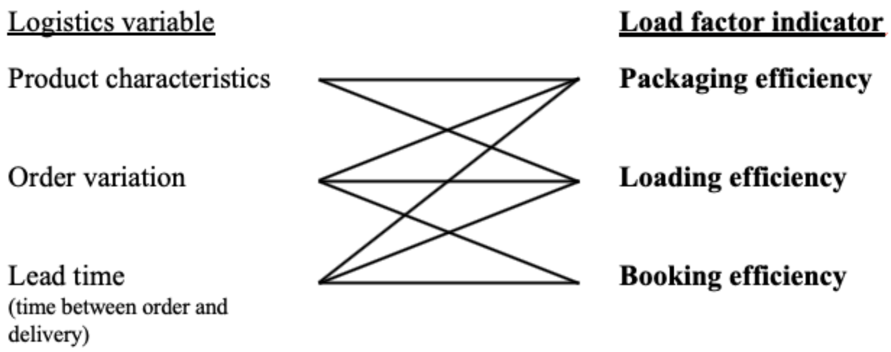


*Figure 6. The load factor framework. Based on Santén (2016).*

If an actor desires to make a change in any of the logistics variables it becomes important to consider the interdependent nature of business relations and resources described by Ford, Gadde, Håkansson, Snehota, & Waluszewski (2008). Changes require collaborations internally, but also across the company borders, as logistics actions influence other actors in the business network (Santén, 2016).

## 2.4 Investment Analysis Using Payback Period Methods

There are several different methods to evaluate the economic attractiveness of an investment (Remer & Nieto, 1995a). Some commonly used methods are net present value (NPV), rate of return methods, and payback methods. All methods provide the possibility to evaluate the profitability of an independent project or to make alternative investments comparable. The methods differ in the required input data, and also in which conclusions can be drawn from the output. For example, NPV methods require an internal rate of return, as well as data about the cash flows for the entire economic life of the investment. The payback period methods only require data about the cash flows within the payback period. The shorter time horizon makes the payback method considered appropriate in this project, as it gives an indication about the risk associated with the project but requires fewer assumptions to be made. An elaboration of the benefits and drawbacks of applying a payback time method follows below.

The main purpose of a payback period method is to determine the time required for a project's earnings to equal a project's investments (Remer & Nieto, 1995b). For a project to be attractive, the payback period must be equal to or shorter than the economic life of the investment. There are two main payback methods, the conventional payback time method and the discounted payback method. The two types of payback methods are applicable in different settings and require slightly different input data. The conventional method assumes an interest rate of zero percent, while the discounted method considers the time value of the invested money. This is done by discounting the annual cash flows using an internal rate of return (IRR). This rate is often set as the weighted average cost of capital, WACC (Yard, 2000).

The cash flows within the payback period must be known or possible to estimate with reasonable certainty. The level of allowed uncertainty must be decided by the decision-maker. Cash flows after the payback period are not taken into consideration in the method. Remer and Nieto (1995b) argue that the disregard for cash flows beyond the payback period is a major disadvantage. There is a risk of assessing two projects as equally good if the payback time is the same, despite a difference in the succeeding cash flows. Therefore, the authors suggest that the payback period method is combined with either a net present value or rate of return method to strengthen the decision making. However, S. Yard (2000) argues that in investment situations where the future cash flows are uncertain, the payback method may be preferred to more advanced analyzes. He explains that the payback period is often used to give a first indication of the attractiveness of the project. Further analysis can then be conducted using the net present value or rate of return methods to give more detailed insights.

The undiscounted payback time can be calculated using the equation

$$0 = I - \sum_{0}^{n} CF_n$$

and the discounted payback time by using the equation

$$0 = I - \sum_{0}^{n} \frac{CF_n}{(1 + IRR)^n}$$

where I=Initial investment, CFn=Cash flow year n, and IRR= Internal rate of return.

The unknown variable that the equations are solved for is n, which is the number of periods to achieve a total project value of zero. The denominator of the discounted formula becomes more prominent as n becomes larger, implying that the impact of the discount rate on the cash flows is larger the further from year 0 of the project the cash flow takes place. As such, the discount rate has more impact on a project that extends over a longer time horizon. Remer and Nieto (1995b) argue that one of the main benefits of the payback period method is that it gives a quick insight into the risk related to the project. It is also easily understood and clear to communicate within the organization.

## 2.5 Sensitivity Analysis

Sensitivity analysis is a practice used to determine how a dependent variable, for example, the result of a calculation, is affected by changes in independent variables under a given set of circumstances (Sheposh, 2019). The analysis gives an understanding of to which extent the underlying factors can be changed before the output or recommendation changes significantly. Sensitivity analysis is commonly used in business decision-making processes to strengthen communication and develop recommendations. The analysis becomes increasingly important if there is much uncertainty related to the underlying factors, as they can substantially affect the output of the model (Lamboni, 2018). As a result, the sensitivity analysis functions as a risk assessment that evaluates the impact of different factors in a business case (Sheposh, 2019).

Wolters and Mareschal (1995) suggest three different types of sensitivity analysis. The first type identifies how much the result will be affected by changes in the data of all alternatives on certain underlying data. The second type determines how changes in the data of a specific alternative on certain criteria will affect the result. The third type identifies the boundaries within which the value is allowed to vary before it significantly affects the result or changes the recommendation. This is done by calculating the minimum modification of the data that is required to affect the result (Wolters & Mareschal, 1995). It is up to the analyst to determine what is considered a significant change in the result. The first method is applicable when there is uncertainty in several factors, such as economic uncertainties. The second type is suitable when there is uncertainty limited to the data of one of the factors. An example presented by Wolters and Mareschal (1995) is if the decision-maker expects a grant for a specific alternative. The third method identifies the boundaries within which the value or values are allowed to vary before the result is affected. The boundaries are found by solving a linear function with constraints. The constraints can involve specific relations that must be kept between certain factors. A drawback of the method is that it does not give any insight as to how much the result is affected outside the boundaries (Wolters & Mareschal, 1995).

# 3 Methodology

The methodology section presents the design of the master thesis and how it is planned to be performed by using both theoretical and empirical data. When designing a research, it is important to consider the context in which the research is embedded. Separation is often made between the research strategy and the research methodology (Denscombe, 2014). The research strategy is described as the plan for the research process and in which order the various activities will be carried out. In section 3.1 the intended design of the study will be presented. The research methodology is explained as the different ways of collecting the data needed in the research, one of the most important activities in the research (Bell, Bryman & Harley, 2018). In section 3.2 the actual activities performed in the research will be described. Following the research strategy and methodology below, a discussion regarding the quality of the research will be held.

## 3.1 Research Strategy

Choosing a research strategy is crucial since it will be a guide to answer the research questions. One strategy brought up by Saunders, Lewis, and Thornhill (2015) is the case study, which is an empirical study of a specific situation within its real context by using several sources of data. When relating this definition to the context of this research and the opportunity to collect data from both ICA and field studies, a case study was considered appropriate. The case study also enables further valuable insights when trying to understand the context better (Saunders et al., 2015). In this research, the main stages of the research process are; the formulation of research questions, literature review, current state mapping, supplier base analysis, and assessment of the impact on annual operating costs. Continuously during the project, the findings and insights will be analyzed and documented in the final report. The project process and its phases are further elaborated below.

The initial phase will focus on thoroughly formulating the research questions, to explicitly know what the research aims to answer. The research questions will also work as guidance when designing the rest of the research (Bell et al., 2018). The formulation of the research questions will be an iterative procedure that also includes doing the literature review and mapping the current state simultaneously.

The literature review will consist of reading academic reports as well as industry papers and magazines, creating a foundation for the theoretical framework of the research. The framework will include theory about warehouse operations, unit loads, load factor, investment analysis, and sensitivity analysis. The purpose of the literature review is to identify previous findings in the areas of research that could be compared to the empirical findings from the case studies and the results from the calculations. Putting literature and empirical findings in relation to each other will enable the analysis and discussion to be synthesized, which is the tool to answer the research questions.

The mapping of the current state will mainly be based on internal data from ICA regarding shipped volumes and data from supplier contracts on current pricing models as well as how the goods are loaded. Collecting empirical data, both qualitative and quantitative, from interviews and warehouse visits, will also contribute to the current state analysis and strengthen the understanding of the eventual implementation of slip sheet at ICA.

Implementing slip sheet requires the right equipment at both the supplier and at ICA, hence understanding for the suppliers' ability to ship on slip sheet is crucial. A supplier base analysis will be done by collecting information directly from the suppliers by sending them a survey related to slip sheet. The survey will make it possible to see the readiness in the supply chain for setting up the new way of shipping.

The impact on the annual operating costs will be analyzed from multiple perspectives. The contextual factors from the empirical findings will be reviewed to identify the preconditions for implementing slip sheet. The quantitative data collected will be used to assess the financial implications of slip sheet at ICA. The assessment calculations will be made by using the payback period method since it is easy to apply and gives a good insight into the risk and potential of a project. The payback period method does not consider the future cash flows beyond the payback period, in contrast to for example net present value (NPV) (Remer & Nieto, 1995b). This is sometimes perceived as a drawback but since container volumes are increasingly difficult to assess further into the future, it is regarded better to only consider the near future and avoid making assumptions that can affect the application and validity of the result. The robustness of the recommendation will be evaluated using sensitivity analysis. One type of sensitivity analysis described by Wolters and Mareschal (1995) will be applied. The first method described was selected to give an understanding of how the result is affected by changes in the underlying factors and provide an insight into how economic uncertainties impact the recommendation. The sensitivity analysis gives insights about the likelihood of a change in the recommendation.

## 3.2 Research Methodology

The formulation of the research questions, the literature review, and the mapping of the current state at ICA were conducted in parallel as an iterative process. This was done since new research areas to include in the framework were found while investigating the current situation, which in turn required modification of the research questions. Data was collected during the studies of the current situation, but also in the process of doing the supplier base and investment analysis. For data collection, various methods can be used and combined (Denscombe, 2014). Primary data collection methods used in this research were internal data from ICA, observations from study visits, interviews, and a survey.

The internal data was mainly quantitative extracts from the databases that enabled the identification of the current container flows, the type of goods being sent, the method for loading the goods, and at which nodes in the warehouse network that goods are being unloaded. The internal data was also used to calculate the impact slip sheet would have on the annual operating costs.

Several study visits were made during the course of the research project. Two study visits were made to ICA's internal warehouse, Warehouse 1, and one to the external warehouse Harbor Cargo in Gothenburg. An additional study visit was made to study the slip sheet operations of the company Big Bolts, to gain insights from a different industry. The first visit to Warehouse 1 fulfilled the purpose of creating a better understanding of the problem and what further studies to conduct. The second visit to Warehouse 1 focused on the internal warehouse operations and interviews with warehouse employees. The external visits to Harbor Cargo and Big Bolts focused on studying current slip sheet unloading processes, which gave insights that were valuable when analyzing the potential implementation at ICA's warehouses, Warehouse 1 and Warehouse 2. At all the field visits, qualitative data was gathered in the form of interviews. Quantitative data was collected in the form of results from time studies previously done by the companies. The data collected from the warehouses were then used for performance comparison between unloading loose-loaded goods and unloading using slip sheet.

Besides the interviews at the study visits, complementary interviews were conducted with people at several positions within ICA's organization to create a holistic understanding of the situation and to align thoughts and ideas. For the supplier analysis, the suppliers shipping the largest volumes were identified from the data and included in a more focused study. To get in contact with the suppliers, meetings were held with the strategic purchasers responsible for each supplier of interest. Five strategic purchasers covered the entire supplier base of interest. The interviews with the strategic purchasers were held according to the semi-structured approach, which is suitable for collecting qualitative data and making sure that the predetermined topics are covered as well as new ones brought up during the interview (Bell et al., 2018). The prepared questions were of the open-ended kind, creating an environment for the interviewee to think and share his or her experiences (Brinkmann & Kvale, 2015). Depending on the answers of the interviewee, the semi-structured approach allows for asking relevant follow-up questions without having to stick to the exact manuscript. The interviews held at the warehouses were slightly more unstructured compared to the ones held with the purchasers because of the uncertainty in what areas that would be included in the study visits. Additional interviews were also held with other internal people involved in, or affected by, the project.

With help from the strategic purchasers, a survey regarding slip sheet was sent to the suppliers to collect data about their ability and willingness to ship the goods on slip sheet. The survey method was chosen because of the possibility to collect large data sets efficiently from a sample of the population, which could represent the entire population (Fowler Jr, 2014). The finding from the survey was used to assess the potential of slip sheet in the entire supplier base. The questions from the survey can be seen in Appendix I.

To get a broader empirical basis for the research, additional information from other external actors having experiences from slip sheet was used to complement the data from ICA. A workshop was held with one actor that was doing a similar potential analysis of slip sheet as the one ICA is doing. In the workshop, experiences and findings were shared and discussed, widening the perspectives on the project even further. The combination of knowledge from several actors gave a more nuanced view on the implications of slip sheet both from a technological and organizational point of view. The external actors were found by contacts recommended by the supervisors.

The use of different data collection methods generated both qualitative and quantitative data, which according to Saunders et al. (2015) means that the research was performed using multiple methods. Integrating different kinds of data by using multiple methods enables a more comprehensive understanding of the research and strengthens the analysis (Creswell, 2014). Beyond strengthening the analysis, the combination of data sources enabled the process of creating a model for the financial impact and evaluating the performance of slip sheet in comparison to loose-loading.

## 3.3 Quality of Research

A key aspect while selecting which method to apply is the resulting validity, reliability, and objectivity of the analysis and conclusions (Björklund & Paulsson, 2014). Validity refers to the extent the method is suitable to answer the research questions at hand. The results obtained from the method should furthermore provide an answer to the research questions. Reliability refers to the ability to achieve the same result if the study is repeated. Objectivity indicates to which extent personal opinions or bias are affecting the result of the study.

To avoid personal opinions and bias from being reflected in the final recommendations, interviews have been conducted with several individuals within the organizations. Using several sources as input to the same subject matter is called triangulation (Denscombe, 2014). The different roles may represent different interests in the matter. Triangulation is often used to strengthen the validity of research and reduce the subjectiveness as there may be more than one "truth" depending on the respondent's position (Flick, 2004, Chapter 4.6). For example, both strategic purchasers, operative purchasers, goods receipt managers, warehouse operators, logistics managers, and packaging specialists have been interviewed, amongst others within the organization of ICA. When possible, the interviewee was sent the material following the interview to give feedback on the notes. This is done to reduce the risk of misinterpretations and promotes a higher level of validity (Griffee, 2005). The practice is sometimes referred to as respondent validation (Denscombe, 2014). Progress evaluation meetings during the course of the project, as well as workshops where experiences from different industries were shared, have been tools to further strengthen the validity.

The validity of data is essential to consider in the quantitative part of the research. The validity of data considers both the quality of the data itself and the suitability to use the data to answer the research questions (Denscombe, 2014). Checking the data for errors is particularly important when the data entry is manually done, which was the case for several of the sources used in the project. As such, additional measures were taken to ensure a high validity of the data used in the project. Since the data used was not gathered for the project, it was important to consider what was included in the measures to ensure appropriate use. By making detailed calculations for some of the suppliers where all necessary data was available, and extending the findings to the remaining suppliers, conclusions about the financial impact could be drawn for all data with different degrees of certainty. By clearly expressing the assumptions the calculations were founded on, and stating how it affects the validity and reliability, it becomes clear to the recipient how to interpret the result.

One method to achieve high reliability in research is to compare the method and findings to earlier studies on the subject matter (Denscombe, 2014). Since the previous academic research on the topic of slip sheet is very limited, additional measures have been applied to achieve a high quality of research. One measure is that the empirical foundation of the project has been extended to include actors from other industries with experience from slip sheet. If similar conclusions were drawn about the applicability of the technology, higher reliability could be considered to be achieved. A broad empirical basis is thought to contribute to a nuanced analysis and gives a higher degree of certainty in the recommendations. In qualitative research, it is generally more difficult to attain high reliability as the researcher is often an integral part of the research method (Denscombe, 2014). As a result, the same result is almost impossible to achieve if the study is repeated by another individual. To ensure high validity, a combination of quantitative and qualitative methods was used. This reduces the personal dependence on the researcher. Another important aspect of reliability is that the calculations and analysis in the research are done in an orderly and correct manner. It is important to consider the accuracy of how the method is applied to achieve high reliability.

Objectivity is difficult to evaluate as the personal reflections from the authors is present in all parts of the research, from formulating the research questions to selecting the method and pursuing the analysis. By combining insights from field studies with theory from a broad theoretical foundation, it is believed that the risk of subjectiveness is reduced. By including insights and experiences from external actors and comparing these to the internal expert knowledge at ICA, a high research quality in terms of objectivity could be achieved. Supplementing the qualitative case studies with quantitative calculations further strengthened the objectivity and reliability of the resulting recommendations.

Regarding the generalization of the findings of the study, Denscombe (2014) highlights the concept of transferability. Since the observed cases are relatively few and qualitative methods are applied, statistical generalization is not suitable. Transferability depicts to what extent the findings of the study may apply to other cases. To provide the reader with tools to evaluate the transferability, it is important to elaborately describe the contextual factors. The transferability of the study will further be discussed in chapter 6 Discussion.

# 4 Empirical Findings

In this chapter, the empirical findings in the project are presented. The findings consist of current state descriptions of the Dry and Non food goods flow at ICA and gives insight to the first research question. In addition to the flows of ICA's products, findings from external actors with experience of slip sheet are presented. These actors are performing in several different types of industries which gives good insights to the applicability of slip sheet in more general terms. All data and information in this section was retrieved from interviews with representatives from the organizations and reflect both objective findings and the opinions of the respondents.

## 4.1 The Current Flow of Loose-Loaded Containerized Goods

The current state descriptions are snapshots of the logistics practices at ICA during the observed period between February 2019 and January 2020. The period was selected both for the data availability in the databases, and because the operations at Harbor Cargo were initiated in the beginning of 2019. Before February 2019, ICA used a different logistics provider. The descriptions of the Dry goods and Non food flows are separated since key differences can be identified in how ICA has designed and are operating the flows of the products. As previously mentioned, this segment will be the foundation to answer the first research question. The chapter segment begins by describing the Non food goods flow, followed by a presentation of the Dry goods flow.

### 4.1.1 Non Food

Below follows a description of the Non food goods flow. Initially the design of the flow is described, followed by descriptions of the receiving operations, the product characteristics, the supplier base and the current slip sheet practice.

#### 4.1.1.1 Design of the Flow

A large share of the goods is ordered in quantities smaller than 45 cubic meters (cbm), which is ICA's limit for making it a LCL shipment. If the ordered quantity is LCL, the goods will be shipped to a consolidation terminal in Asia to be jointly loaded with other goods before the container is shipped to ICA. Some issues related to achieving a high load factor may arise at the consolidation due to the difference in dimensions of the items that need to be stacked together. If the order volume is above 45 cbm already at the supplier, the container is considered as FCL and shipped directly from the supplier to ICA.

The containerized Non food goods arrive at ICA's own warehouses Warehouse 1 and Warehouse 2. The annual volume is approximately 1600 TEUs. About 80% of the volume is sent to Warehouse 1, and the remaining 20% of the volume is shipped to Warehouse 2. The bulky goods flow to Warehouse 2 while more regularly shaped goods are sent to Warehouse 1.

The vast majority of Non food goods arrive loose-loaded, with the exception of some items such as batteries that arrive on simple wooden pallets and candles that arrive on a paper pallet. Regular 20-foot and 40-foot containers are used in the flow as well as high-cube containers, which are higher than regular containers to fit a larger volume. The division between the types of containers is shown in Table 1. The order policy for the Non food flow is to order according to the actual demand. No consideration is taken to make sure the ordered volume can be fit on an even number of pallets or that it fills the container. Since it is possible to consolidate shipments, it is not necessary to optimize the order volume in each order to achieve a high load factor in the container.

*Table 1. The different container types used in the Non food goods flow.*

| Container Size | Share of Annual Volume |
|---|---|
| 20-foot | 24% |
| 40-foot | 31% |
| 40-foot high-cube | 45% |

#### **4.1.1.2** Receiving Operations

The majority of goods arrive loose-loaded to the warehouses and the receiving operations are similar in both Warehouse 1 and Warehouse 2. Two operators work inside the container and unload goods onto pallets. An additional operator ensures that the goods are stacked according to the stack pattern and operates a forklift to carry out full pallets and replenish empty pallets to the unloading operators. A fourth operator may assist in the plastic wrapping of the pallets, which is done using a stretch wrap machine.

As mentioned before, some of the goods arrive on pallets. The pallets that arrive from the suppliers are of varying quality, such as paper pallets and thin wooden pallets. ICA has a policy to only use EUR-pallets with certificates in the warehouses, and as such all palletized goods must be transferred to a new pallet of approved quality. Either the inferior pallet is simply placed on top of a EUR-pallet, or the goods are repacked onto the EUR-pallet. The transfer to an approved pallet can be done by manually repacking the goods or by using a machine that flips the load upside down, enabling the replacement of the pallet before flipping it back.

#### **4.1.1.3** Product Characteristics and Supplier Base

The Non food assortment is wide and the volume per item number is generally low. A large share of the assortment is bulky goods, such as garden tools, brooms, and barbeques. The products are characterized by strong seasonality and frequent updates in the assortment. Some items that are an exception to the seasonal variations are candles, light bulbs, and batteries, in contrast to for example holiday ornaments and garden accessories where the seasonality is pronounced.

The supplier relationships in the Non food segment are generally short term relationships. The suppliers are frequently changed to keep the assortment updated according to customer demand. Some suppliers are only used once, and some are only used for certain seasons. A few relationships are more long term, for example, suppliers of candles and light bulbs. As a result, the relationships with the suppliers are generally distant and there is little ongoing communication. During the studied period in the project, over 250 suppliers were used in the Non food segment. 40% of the suppliers shipped less than one TEU per year. Due to the frequent changes in assortment and supplier base, the knowledge and compliance regarding box dimensions are sometimes lacking. Occasionally the products arrive in a different sized box than what has been agreed, which can create issues in palletizing the goods upon arrival, as the stack pattern no longer is valid.

#### **4.1.1.4** Current Slip Sheet Practice

During the period observed in this project, February 2019 to January 2020 no goods were sent on slip sheet in the Non food flow. For the FCL flow of Non food goods, ICA has no prior experience of working with slip sheet. However, a pilot project with slip sheet was performed about ten years earlier in the LCL flow. The project was carried out in collaboration with the third-party logistics provider Fast Freight at their terminal in Shanghai. The scope of the project was the LCL shipments that pass the consolidation terminal before being shipped to Sweden. Equipment to form unit loads and handle them on slip sheets already existed at the terminal. The products concerned were cleaning products and clothing items. To the extent possible, the items were stacked in pallet-sized unit loads with only one item number in each load. When necessary, mixed product pallets were created to load the residual items.

Due to three main reasons, the project turned out to be unsatisfactory and the use of slip sheet was never rolled out. The first reason was that it was a demanding task to supply the consolidation terminal with accurate stack patterns. The information sharing between ICA and Fast Freight didn't function well enough, which resulted in less productivity and delays.

The second issue, which is closely related to the first, was that the delivered distribution box dimensions often differed from the agreed dimensions in the contract. This resulted in that it was impossible to use the stack patterns for the products, or that the distribution boxes were turned on a high end to fit the goods regardless. The changed box dimensions resulted in poor loading efficiency, additional repacking, longer lead times, or a combination of all.

The third and final identified issue was the complex handling of slip sheets containing more than one type of product. Since the order volumes in the Non food flow are not optimized to be multiples of pallets or containers, odd distribution boxes of items that cannot be fit with the rest of the goods are common. To achieve efficiency in handling at the consolidation terminal, these odd boxes were combined into mixed product pallets. It was a critical issue to mark the mixed product pallets with stickers so that they could be recognized as exceptions in the unloading operations. The mixed product pallets were split upon arrival to ensure only one type of goods on each pallet in the warehouse. This resulted in manual labor with caution to ensure the correct splitting of the items.

### 4.1.2 Dry Goods

Below follows a description of the Dry goods flow. The section begins by describing the intended design of the flow, followed by descriptions of the receiving operations, the product characteristics, the supplier base, and the current slip sheet practice.

#### **4.1.2.1** Design of the Flow

All containerized Dry goods are shipped from the suppliers to the external warehouse Harbor Cargo in Gothenburg. The annual volume is approximately 2000 TEUs. The goods arrive in three different formats; palletized, loose-loaded, or on slip sheet. About 2% of the annual volume is loaded on slip sheet and the rest are almost equal parts palletized and loose-loaded. The exact figures can be seen in Table 2 below. The reason information is missing for about one percent of the volume is that the file where the data is extracted from is manually filled in. Both 20-foot and 40-foot containers are used in the flow, but the majority of the volume arrives in 20-foot containers. The order volumes are always multiples of entire containers and never less. If the demand is less than a complete container, other item numbers from the same supplier are added depending on the current stock level in the warehouse.

*Table 2. The share of the annual container volume per loading practice.*

| **Loading Practice** | **Share of Annual Volume** |
|---|---|
| Loose-loaded | 52% |
| Palletized | 45% |
| Slip sheet | 2% |
| Information missing | 1% |

#### **4.1.2.2** Receiving Operations

Upon arrival to Harbor Cargo, loose-loaded containers are opened, and one or two operators begin unloading the goods onto pallets. The operators at Harbor Cargo are supplied with a stack pattern from ICA to create correct unit loads for the continued flow. The pallets are then wrapped in stretch wrap before they continue in the flow.

Palletized containers are unloaded using a forklift and most frequently require no further handling. If the goods are loaded in two layers, they are split. If the arriving pallet is of inferior quality, it is placed on top of a certified EUR-pallet. Containers loaded with slip sheets are unloaded using a push/pull attachment. The goods arrive stacked in two or more layers. The entire stack is first unloaded and put on a pallet. The top layer is then separated from the stack by pushing the slip sheet with the push/pull attachment onto a forklift. This operation requires two forklifts and one attachment. The procedure is then repeated until all unit loads are separated and put on individual pallets. When handling the goods on slip sheet, some room must be left at the top of the container to provide maneuvering space for the forklift attachment. As such the entire internal height of the container cannot be utilized. After unloading and palletizing the goods, the pallet is either put in storage until demand arises or is cross-docked and forwarded directly to any of ICA's distribution units or central warehouses.

#### **4.1.2.3** Product Characteristics and Supplier Base

The products in the Dry segment have generally been included in the assortment for a long period. The product design and packaging have also been consistent over time, resulting in good knowledge and compliance with the box dimensions. The distribution box dimensions are allowed to vary +/- 4% from the agreed measures. The assortment consists of relatively few unique item numbers with high annual volumes. To achieve economies of scale in shipping, the order size is always optimized to achieve full container loads from the same suppliers. As a result, no containers require consolidation but may contain several different items from the same supplier. The supplier relationships are generally long term and the contracts are renegotiated annually or in some cases more frequently.

#### **4.1.2.4** Current Slip Sheet Practice

About two percent of the annual TEUs of Dry goods arrive in a relatively well-functioning slip sheet flow during the observed period. Representatives from Harbor Cargo state that some additional containers arrive on slip sheet, but with other measures than the EUR-pallet. If the dimensions of the sheets are not in EUR-pallet dimensions, the shipment must be treated as a loose-loaded container and be repacked on EUR-pallets to be able to continue in the flow. This type of shipment is debited as a loose-loaded container. The relation between the rates for unloading loose-loaded containers and containers loaded on slip sheet can be seen in Table 3.

*Table 3. A relation between the savings per container being handled at Harbor Cargo.*

| **Harbor Cargo** | **Savings** |
|---|---|
| 20-foot container | x SEK |
| 40-foot container | 2,4x SEK |
| Additional fee for 20-foot container with > 3000 distribution boxes | 1,3x SEK |

The goods arriving on slip sheet are perceived to be less damaged compared to loose-loaded goods since there is less risk of collapse when the distribution boxes are put together as unit loads. However, the goods can at times be damaged during handling because of the difficulty in maneuvering the slip sheet attachment mounted on the forklift. In addition to receiving goods loaded on slip sheet on the behalf of ICA, the external warehouse Harbor Cargo has also experienced an increasing interest from other customers to ship on slip sheet.

The purchasers responsible for the goods in the containerized flows have different levels of understanding and knowledge about the shipping procedure of the goods. For a large share of the goods shipped from Asia, ICA negotiates jointly with a Finnish grocery chain that utilizes slip sheet to a much larger extent. As such, it is known that many of the suppliers can offer slip sheet to their customers, it is just not quoted for by ICA. There is no common framework for the purchasers to determine the most suitable way the goods should be shipped. As a consequence, some purchasers state that the loading procedure is not a central matter in the negotiations and that the result is little insight about how the goods are loaded.

## 4.2 External Actors

Below follows a description of the external actors included in the study. The actors represent different types of industries and all have previous experience from slip sheet. Since the context in which the different actors operate differs somewhat from ICA's environment, interviewing them contributed with different perspectives and insights to be used in the analysis. Visiting one of them to see the operations live also contributed to an additional understanding of the slip sheet technology and the demands that it puts on the organization.

### 4.2.1 Big Bolts

The first actor, further called Big Bolts, is active within the manufacturing and construction materials sector. Big Bolts has carefully developed a flow of screws and bolts to be shipped on slip sheets. Big Bolts have been shipping on slip sheet for about seven years and the technology was initially implemented as a way to increase the load factor of the containers. The products were previously shipped on pallets and by replacing the pallets with slip sheets, Big Bolts managed to increase the load factor in the containers by approximately 25% to 30%. Space previously occupied by the pallets could be used to fit one extra layer of products. It was still not possible to use the complete height of the container since some space is required to maneuver the forklift attachment. The slip sheets arrive at the warehouse stacked in three levels. The stacks are transported out of the containers and split into three separate pallets in the warehouse. The increased volume of products in each container reduced the total number of shipped containers and thereby decreased the annual shipping cost.

Beyond the major positive effects of increased load factor and decreased shipping costs, other effects on the organization were described. One of the effects was a reduced need for storing and handling pallets in the warehouse. The shipping pallets used by the suppliers previously were generally of poor quality and there was a need to transfer the goods to a EUR-pallet upon arrival. The operation required storing empty EUR-pallets near the receiving area and recycling bins to handle the scrapped inferior pallets. The slip sheet setup requires a lot less space in the warehouse compared to the previous solution. The slip sheets are used once and are collected for recycling after use.

One factor making the implementation worthwhile for Big Bolts was the high volume in the product flow, providing the possibility to fill the containers with only one type of product. The small and uniform size of the boxes were good for stacking. Some redesign of the carton board boxes was made to create more stable stacks and reduce the air pockets in the boxes. The new design prevented collapsed and damaged boxes. The load was further strengthened by putting vertical carton boards as a skeleton through the middle of the stack. Additionally, corner protection was attached to the load to reduce the risk of goods damages. Since Big Bolts are shipping heavy fastening products on slip sheet, the quality of the slip sheet was critical for a successful outcome. The quality was developed in collaboration with the supplier by sending test shipments to find a slip sheet robust enough. The slip sheet used today is a carton board strengthened with plastic fibers. The cost of the sheet is about 40 SEK, compared to the price of a shipping pallet that is about 86 SEK. It was perceived by the operators that there were less damaged goods after implementing slip sheet. Potential contributing factors were expressed as the improved packaging, the ability to place the stacks close to each other with no room in between, and the increased stability of putting the product directly on the floor compared to on pallets. A prerequisite for keeping the load secured in the container was to anchor the goods properly by for example straps and airbags.

Big Bolts has one push/pull attachment, which is sufficient to receive approximately three containers each day, year-round. The high dependence on the attachment in the unloading operations has also led them to store their old attachment as a backup, in case of breakdown or maintenance. According to the operators, service of the attachment is rarely needed, and the attachment could easily be demounted in case the forklift is needed for other warehouse operations.

A drawback of slip sheet that was brought up during the visit was the additional skills required to use the push/pull attachment. Compared to unloading regular pallets, it was described to be slightly more difficult to unload slip sheet. More caution is required from the operator as there is a risk of pushing the attachment into the goods while trying to grip the tab. As a consequence, the unloading of slip sheet takes slightly more time compared to handling regular pallets. However, no specific certificate is required for unloading slip sheet, the operators only need to practice and develop the required skills.

The continuous improvements made when implementing slip sheet were possible because of the close relationship between Big Bolts and their supplier. The ability to follow up and communicate with the supplier was considered critical for the implementation to be successful. The possibility to implement slip sheet was also related to the volumes of goods. The high volumes created negotiation power that facilitated the implementation. The negotiation power was key for Big Bolts in order to put requirements on the quality of the slip sheets and the loading of the goods. Big Bolts also showed the attractiveness of slip sheet by creating a business case for the suppliers indicating the saving potential on their end, including for example the price difference between slip sheet and pallets.

Big Bolts expressed a wish to receive more products on slip sheets because of the ease of unloading and the opportunity to increase the load factor in the containers. However, due to too small volumes and less suitable box designs, no other suppliers are interesting to transfer to slip sheet at the moment.

### 4.2.2 Global Furniture

The second actor, further called Global Furniture, is a furniture company with a global supply chain and warehouses all around the world. During the interview, it was described how Global Furniture once evaluated slip sheet but then decided to not use it on a larger scale. Although Global Furniture is not using slip sheet the findings from the interview contributed with knowledge about critical factors and situations where slip sheet might not be favorable.

The idea of slip sheet was explained to be very attractive for Global Furniture since the company ships products worldwide and is constantly looking to improve the company's logistics efficiency. The evaluation of slip sheet was done in comparison to shipping on a pallet. Global furniture made a decision to avoid loose-loading about 30 years ago because of the required manual labor and the non-existent compatibility with automation. In the discussion, the wage development in China was brought up. It was mentioned that the wage levels are continuously rising, and that the importance of efficient goods handling is increasing at the supplier end as well. Global Furniture's vision is to use the same unit load in the entire product flow, from the supplier to the end consumer. The aim is to create the unit load at the suppliers and not break or modify it until the end consumer collects the consumer box in the store. Slip sheet could not fulfill the aim since a supporting pallet is required to store the slip sheet in the pallet rackings of the warehouses. It was concluded by Global Furniture that slip sheet could be advantageous in flows from point A to point B, but not if the slip sheets are to be handled at several nodes since a high dependency on the special push/pull forklift attachments would surface.

Despite the relative benefit of an increased load factor when using slip sheet, Global Furniture decided to progress with an entirely different solution. A paper pallet was created, that utilizes the dimension of the container better than regular wooden pallets and that is sturdy enough to use on its own in the pallet rackings. Creating their own paper pallet enabled Global Furniture to utilize the entire width, length, and height of a container, except for the space needed for maneuvering the pallet inside the container. Global Furniture also explains that the implementation of the customized pallets took several years and that it was possible because of the high volumes shipped and their negotiation power towards the suppliers.

### 4.2.3 Home Decor

The third external company, further called Home Decor, is an actor within the sector of table-setting and packaging solutions. As part of a bigger supply chain transformation, Home Decor is doing a potential analysis of slip sheet similar to the one at ICA. A workshop was set up to share findings and reflections regarding the use of slip sheet. The purpose of both projects regards an evaluation of the transformation from shipping loose-loaded to using slip sheet and the potential of increasing the unloading efficiency at the warehouses.

A central topic of the workshop was the role of the supplier in a slip sheet implementation. Home Decor described a difficulty in making the technology attractive for the supplier since slip sheet might require additional work and investments compared to loose-loading, leading to higher rates. The relationship to the supplier was described as crucial for the implementation, since Home Decor saw that adjustments would have to be made before a well-functioning solution was found in terms of for example slip sheet quality. Collaborating in the implementation would require regular audits and that that the suppliers prioritize the matter as well.

Another topic discussed was the impact slip sheet has on the load factor. According to the calculations made by Home Decor, the load factor was considered as the biggest issue. Firstly, the distribution boxes used today were not optimized to utilize the load factor of the pallet, creating a poor load factor in the unit loads. Secondly, the combined height of two loaded slip sheets still left a lot of space left to the container ceiling. Lastly, the slip sheet dimensions were described to not fit perfectly into a container, regarding width and length. Relating to the load factor on the pallets, a proposition was made by Home Decor to integrate the packaging team to a greater extent and redesign the boxes. One potential solution to better utilize the height was to place half pallets on top of the stacks. Affecting the width and length of the slip sheets is complex due to the standard dimensions of a EUR-pallet and container. Another idea related to utilizing the container was to make the slip sheet dimensions slightly smaller than the EUR-pallet dimensions to fit three sheets in the width of the container and to better utilize the container volume. However, this would lead to a decreased load factor in the continued flow. Home Decor expressed that the difficulty to utilize the volume of the containers was a potential reason to discontinue the project related to slip sheet.

# 5 Analysis

In this master thesis, the attractiveness of implementing slip sheet is desired to be known. The chapter will be divided into two sections; investigation of the potential of slip sheet and additional effects that must be considered in the case of an eventual implementation. The potential of slip sheet will be evaluated by identifying the contextual factors of the organization, the ability of the suppliers to change shipping method, and what financial impact slip sheet will have on the existing practice. In the assessment of the potential of slip sheet, the Non food and Dry goods flow will be evaluated separately due to the distinct characteristics of the products and design of the shipping flows.

In the analysis, theory from the theoretical framework and findings from the empirical findings will be put in relation to each other. The analysis will be structured to cover the topics of the research questions, beginning with the second question related to the immediate effects and potential of slip sheet. The first research question, regarding the current state mapping of the Non food and the Dry goods flow, is already covered in section 4 Empirical Findings. Finally, the third research question about additional considerations of the technology will be targeted. The results from the analysis will be discussed in relation to the purpose and research questions in the following chapter 6 Discussion and summarized in the conclusion, 7 Conclusion.

## 5.1 Potential for Conversion to Slip Sheet

As stated by Ford et al. (2008), activities and resources in the Supply chain are interdependent. This means that changes are likely to affect more than just the actor initiating the change, and mobilization of other actors to adapt to a new solution may be required. Switching the loading method from loose-loaded to slip sheet affects both ICA and the suppliers since for example the handling equipment, such as an attachment and a forklift must exist both at the sender's and receiver's end, as expressed by Lumsden (2007). As such it is important to take a holistic perspective in the analysis of the potential of slip sheet. For the purpose of this report, the potential of slip sheet will be evaluated by investigating and analyzing four areas; the contextual factors, the supplier base, the investment requirements, and the impact on annual expenses which includes a sensitivity analysis. By identifying the contextual factors, it will be possible to understand whether the slip sheet technology is suitable for ICA. Following that, the analysis of the supplier base will be presented to give insight regarding the availability of the slip sheet technology in the supplier base. Further, the required investments for implementing slip sheet at ICA will be presented. In addition to the investments, a conversion to slip sheet will have an ongoing effect on the annual operating costs. The costs can either be reduced or increased depending on how the operations are affected by the transition. According to Lumsden (2007), savings in materials handling can decrease the total transport cost. Further, he argues that a unitization should be done if these savings are greater than the associated costs of implementing the unit load. The savings from the unloading operations will, therefore, be compared to the additional costs in order to see the potential in the conversion to slip sheet. If the potential is positive, savings are generated by converting the flow to slip sheet. If the potential is negative, the conversion to slip sheet would incur greater costs than the existing solution. Finally, a sensitivity analysis of the acquired result will be presented to assess the robustness of the findings. Since the Dry goods flow and the Non food flow differ in the way they are operated, the potential for Non food to change to slip sheet will be presented separately below.

### 5.1.1 Non Food

Below follows the analysis of the potential for conversion to slip sheet in the Non food goods flow. The analysis will begin by evaluating the context of the flow, and what conditions it poses to the transition. Next follows a supplier base analysis, where the readiness of the supplier base will be assessed. Following that, the investment requirements in terms of for example equipment are presented. After that, the financial impact of the transition is explained. Finally, a conclusion about the total potential of the segment is presented.

#### 5.1.1.1 Contextual Factors

The Non food goods flow is characterized by a wide assortment of goods with varying dimensions and features. There are strong seasonal variations in the order volumes, in particular for decoration items. Most item numbers are ordered in small volumes. Some of the items have large annual volumes and display less seasonality, but they already arrive on some type of pallet, which means there is little or no savings potential to be extracted in the receiving operations. A large share of the assortment is bulky goods. Items such as garden tools, brooms, and barbeques are not homogenous and proportional. According to Castetter (2019), these types of items are difficult to load efficiently on a slip sheet. In addition to bulky goods, there are issues with frequent changes in distribution box sizes. The distribution box dimensions are agreed upon in a contract before the purchase takes place. However, it is not unusual that the goods arrive in a different sized box than agreed, without prior notice. Reasons for this may be that the right-sized boxes are out of stock or simply that the contractual agreement is ignored. The changes in the distribution box dimension make it a straining task to update and provide accurate stack patterns. As stated by Kay (2012) it is difficult to find the optimal pattern on a pallet, and if this task must be repeated often due to changes in the dimensions it becomes a tedious and time-consuming task. The issue of communicating the stack pattern to the supplier can further become complicated due to time differences.

The order policy for the Non food flow is to order according to actual demand, and not multiples of pallet loads or container loads. The policy creates some issues as the ordered number of distribution boxes may not build up to complete pallet-sized unit loads in all cases. The odd packages must either be put on top of the even stacks, which creates uneven tops, or be consolidated in mixed product pallets. The mixed product pallets cannot continue past the goods receiving, as only one item number is allowed per pallet in the pallet rackings for administrative purposes. The option is to either put each item number on a separate pallet with a poor load factor, or to wait until additional identical items arrive and can be loaded jointly, both which contradicts two of the unit load principles presented by Ackerman (1990); that the unit loads should be as large as can be practically handled, and handled as few times as possible. If the goods are instead put on top of an even layer in the load, it may no longer be possible to stack the unit loads in the container. The inability to stack the unit loads contradicts the theory presented by Lumsden (2007), stating that a unit load must be stable enough to be stacked with other unit loads. The requirement for evenly stacked layers when using slip sheet is further highlighted by Johnson (1980). Bortfeldt and Wäscher (2013) state that all constraints, such as weight, volume, and stacking limitations must be considered in optimizing the filling of a container. The inability to stack the slip sheets would create new constraints that make it impossible to achieve a good load factor in the container. The issues related to the order volumes were also some of the main reasons that the pilot project with Non food goods on slip sheet was deemed unsuccessful, as described in 4.1.1.4. Current Slip Sheet Practice. Following the logic of Castetter (2019) there is a poor return on investment on putting items that are not suitable on slip sheets as the savings incurred are marginal.

To summarize the contextual factors, there are several aspects that make the implementation of slip sheet seem unattractive in the Non food flow. The product characteristics with a high degree of seasonality and bulky goods, the issues related to updating stack patterns, and the difficulty of achieving a high load factor are all speaking to the disadvantage of slip sheet. The items that are best suited for loading on slip sheet are already arriving on some type of pallet today and as a result, there is no savings potential in a transition to slip sheet.

#### 5.1.1.2 Supplier Base Analysis

The supplier base for Non food goods is wide, which can be seen in Figure 7 below. The suppliers in black are the 14 largest, which have been studied in detail. During the studied period over 250 suppliers were used. Some suppliers were only purchased from once, while some suppliers have a more long-term relationship with ICA.

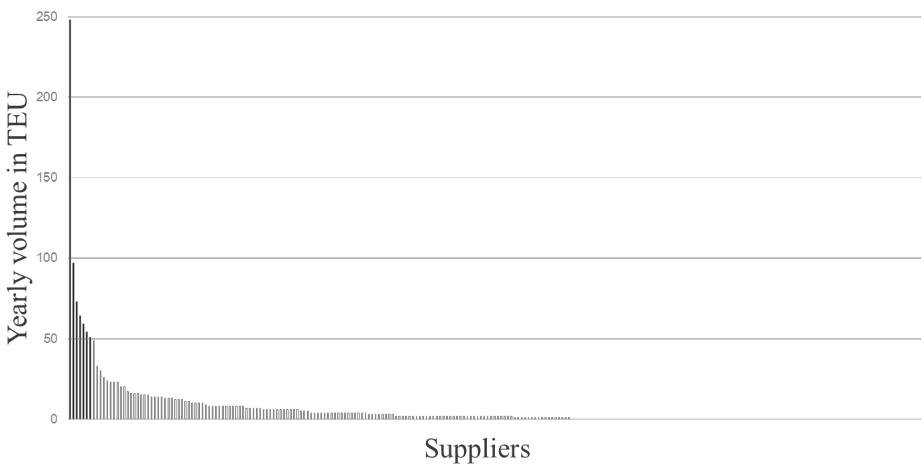


*Figure 7. A chart showing the suppliers in the Non food flow in descending order according to annual container volume.*

The use of slip sheet requires the suppliers to have the proper equipment to create and handle the unit loads (Bouma & Shaffer, 1982). A transition to slip sheet therefore often requires some degree of collaboration, where the sending and receiving party join forces to achieve a sufficiently good solution. This was the case for Big Bolts who demonstrated a well-functioning slip sheet operation, a result of extensive collaboration over a long period of time. The required collaboration regards both the quality of the slip sheet itself, as well as the quality of the stacking and loading in the container. To reduce the effort required by ICA and achieve economies of scale, it is preferred that he shipped volumes are concentrated to a few large suppliers. The concentration enables closer collaborations and more frequent feedback than if relationships must be built with a multitude of suppliers. For this report, the 14 largest suppliers of containerized goods were contacted to map the availability of the technology. These 14 suppliers accounted for 53% of the total annual container volume. Apart from the 14 largest suppliers, the order volumes in the segment are scattered across the supplier base. About 40% of the suppliers send less than one TEU per year, making it difficult to realize the potential without excessive effort.

The 14 largest suppliers were sent a short survey which aimed to give insight about the supplier's possibility to use slip sheet and information on how much goods could be fit into a container loaded with slip sheet and a loose-loaded container respectively. The questions included in the survey can be seen in Appendix I. Due to the strained situation following the outbreak of COVID-19, 50% of the prompted suppliers did not respond to the survey despite reminders. However, amongst the seven suppliers that did respond, 85% offered the possibility to ship goods on slip sheet with EUR-pallet dimensions. It was not clearly stated whether the suppliers used the technology for other customers already.

#### 5.1.1.3 Investment Requirements

The Non food goods container flow is currently designed to originate at the supplier or a consolidation terminal in Asia, depending on the ordered volume, as described in 4.1.1.1. Design of the Flow. All containers are emptied by ICA in their internal warehouses, Warehouse 1 and Warehouse 2. Today, ICA has no equipment to handle slip sheet in either of the receiving warehouses. As expressed by Lumsden (2007), a prerequisite for using unit loads is that the right equipment exists at all nodes where the unit loads are being handled. Bouma (1980) states that a warehouse receiving goods on slip sheet that does not have the right equipment cannot take part in the gains that originate in the simplification of the materials handling. The minimum required equipment to be able to handle containers loaded on slip sheet is a forklift with the right fittings for hydraulics, and an attachment to handle the goods. As stated by Meijer Handling Solutions (n.d.-a), rollerforks can only handle single stacked goods. Since it is preferred to stack goods in two or more layers in the containers, a push/pull attachment is considered appropriate. Push/pull attachments are used by both Harbor Cargo and Big Bolts. The attachment is popular since it is easy to detach in case the forklift is required for other warehouse operations (B&B Attachments, 2017). In Warehouse 1 there are two forklifts with excess capacity available. In Warehouse 2, one forklift with free capacity is available. In both cases, the forklifts must be equipped with the right hydraulic connections to be able to handle slip sheets. The cost of fitting a forklift with the right hydraulic attachment and the investment cost of a push/pull attachment is presented in Table 4.

*Table 4. Prices for obtaining the equipment to handle slip sheet in ICA's warehouses.*

| **Item** | **Cost** |
|---|---|
| Hydraulic connections for forklift | 45 000 SEK |
| Push/pull attachment | 85 000 - 110 000 SEK |

#### 5.1.1.4 Impact on Annual Operating Costs

To understand the impact a transition to slip sheet would have on the annual operating costs, the potential savings and incurred costs must be identified for each supplier that is considered appropriate to target for conversion.

The savings potential for the Non food flow is derived from the reduction in man-hours at the receiving operations in the internal warehouses. To estimate the savings, time estimates for unloading have been collected from operators and managers in the receiving operations. The time estimates have then been multiplied by the average cost of warehouse employees. The time required to unload a container varies much depending on the content and how it is loaded. The loose-loaded containers must be emptied manually. A loose-loaded container with few, light distribution boxes can be emptied rapidly, while fragile, small, and heavy distribution boxes require more time to be unloaded. The inherent variation in human labor further leads to a high variation in the time for unloading operations. The estimated time for unloading a container ranges from 9 to 12 hours. Some containers were reported to take as much as 24 hours to unload as the goods inside required certain caution. If there has been a collapse in the stacking of the goods, which is common for some types of loose-loaded goods, excess handling, and registration of the damages must be done in addition to the unloading. The staffing in the internal warehouses is a combination of in-house employees and additional resources from staffing agencies. As such, ICA has relatively high flexibility in adjusting the capacity to the existing demands. The scheduling of staff is done once per week, based on forecasts for the incoming volumes. The uncertainty in both the forecasts and the time required for unloading requires ICA to schedule excess capacity in the receiving operations, following the reasoning presented by Wruck et al. (2017). The knowledge about the incoming shipments is predominantly low. The operators are generally not certain of the content and how it is loaded until the container has been opened in the warehouse. Some of the uncertainty can be reduced by relying on historical data about the shipments from a certain supplier. However, the high turnover rate in the supplier base and the frequent changes in distribution box dimensions without prior notice reduces the ability to rely on the content of prior shipments. With better knowledge about the content, it would be easier to allocate resources and staff to the receiving operations, which relates to the theories of Gu et al. (2007).

The significant difference in handling time for palletized and loose-loaded goods is well aligned with McDonald's (2016) previous findings, saying that loose-loaded goods often requires two to six times longer time for unloading than palletized goods. This indicates that savings in handling costs can be generated in a transition from loose-loaded to slip sheet. However, it is important to remember that if the reduced required time and variation in the unloading process cannot be translated to a reduced cost of staff, no reduction in the annual operation costs will be generated. It is likely that the reduced costs cannot be derived from the start, but over time as the new operations are settled and the organization adapts. For the goods that already arrive on some type of pallet, no further savings can be generated.

The annual operating costs are affected if part of, or all the volume is transferred to slip sheet. The volumes and suppliers that would be suitable to transfer to slip sheet should have the following characteristics; Sufficiently large supplier in terms of annual volume with little seasonal variation, a homogeneous assortment that is suitable to stack evenly on a slip sheet, few item numbers loaded in the same container, current loading procedure is loose-loaded. In the existing Non food flow, no such volumes or suppliers exist.

The largest supplier, sending candles, currently ships the goods on a carton board pallet, resulting in no savings in the receiving operations. This is the case for at least two more large suppliers that ship light bulbs and batteries. The remaining large suppliers either ship items with strong seasonal variance and many item numbers in the same containers, such as Christmas ornaments, or bulky goods, such as swimming pools and barbeques. These suppliers are not appropriate to convert to slip sheet.

#### 5.1.1.5 Concluding Remarks

The potential for conversion to slip sheet in the Non food goods flow is non-existent. The order policy that creates uneven or mixed product pallets, in combination with a strong seasonal variation, and the scattered order volumes across the supplier base provides a poor possibility for a positive result for the majority of products. For some of the item numbers that have high volumes and less seasonality, other unit loads such as paper pallets are already in use, which eliminates the savings potential from a potential conversion to slip sheet. The characteristics of the Non food flow are summarized in Table 5 below.

*Table 5. A summary of the contextual factors for the Non food goods segment.*

| Contextual Factor | Non Food |
|---|---|
| Assortment | Wide |
| Seasonality | High |
| Product characteristics | Heterogeneous and Bulky |
| Distribution box dimensions | Frequently changing |
| Compliance with agreed distribution box dimensions | Poor |
| Stack pattern | Difficult to maintain |
| Order behavior | Order according to demand |
| Order volume | Low |
| Flow of goods | >45 cbm: From supplier directly to ICA<br><45 cbm: From supplier, via consolidation terminal to ICA |
| Supplier relationships | Short term |
| Supplier base | Wide |
| Slip sheet compatibility | Poor |

### 5.1.2 Dry Goods

In the following section, the assessment of implementing slip sheet in the Dry goods flow at ICA will be presented. Initially, the context in which the Dry goods flow is embedded will be described to assess whether implementing slip sheet is suitable or not. Following, the analysis of the Dry goods supplier base is presented since the suppliers' ability to ship on slip sheet is a prerequisite for using the technology. Implementing slip sheet requires certain investments that later will be declared, followed by the impact the potential technology conversion will have on the ongoing operating costs. The last part of this section will present a sensitivity analysis that assesses the robustness of the findings that form the foundation for the recommendations to ICA.

#### 5.1.2.1 Contextual Factors

The Dry goods flow comprises long-lasting products such as rice, canned vegetables, and dried fruit. The demand for this kind of food is stable and there are no clear seasonal variations as in the case for the Non food goods. Following the steady demand, the assortment is not changed that often and hence the distribution box sizes can be agreed upon with the supplier and kept constant for a longer period. The high compliance with the agreed box dimensions makes it possible to maintain a stacking pattern on the pallet which can be optimized over time. Further, the distribution boxes in the Dry goods flow are often homogenous and good for stacking on top of each other, making them compatible with the use of slip sheet (Castetter, 2019). Another factor making products compatible with slip sheet is the possibility to stack them in multiple layers, creating a unit load (Johnson, 1980). In the Dry goods flow, it is possible to stack the uniform distribution boxes to create a robust unit load, making them appropriate for slip sheet.

In the Dry goods flow, the volumes of goods sold are consolidated to a relatively small supplier base, opposite to the Non food goods flow. The relationships to the suppliers are generally long-term and the order volumes are high for many of the suppliers. Full containers are shipped directly from the supplier and the order volumes are optimized according to the maximum capacity of a container. Sending full containers directly from the supplier makes the loading on slip sheet advantageous since the unit load can be created at the supplier site and kept complete until it reaches the warehouse. This is in accordance with the theory put forward by Lumsden (2007), advocating that unit loads are ideally formed at the supplier and broken at the end customer. It also follows Ackerman's (1990) principles about handling the material as few times as possible and that the use of mechanical equipment should be preferred over manual labor. By creating a unit load on slip sheet instead of handling the distribution boxes manually, the material handling operations will be benefited economically (Buoma, 1980; Spencer & Ebeling, 2011). A conversion to slip sheet would eventuate less time spent in receiving operations, since the time needed for unloading is, for instance, dependent on the number of units to handle and whether they can be handled manually or mechanically (Gu et al., 2007).

Spencer and Ebeling (2011) express that keys for succeeding with slip sheet are for example the communication and follow-up with suppliers. The existing long-term relationships ICA has with suppliers of Dry goods is therefore advantageous. Additionally, having a stacking pattern not exposed to frequent changes is favorable when using slip sheet since it facilitates communication with the suppliers and makes it possible to have consistency in the loading of containers.

To summarize the findings of the contextual factors, there are good preconditions to implement slip sheet in the Dry goods flow. Both the product dimensions and the order behavior provide good opportunities to stack the products and avoid multiple handling, contrary to the case for Non food. The small supplier base characterized by long term relationships further provides a good possibility to develop and maintain the slip sheet solution.

#### 5.1.2.2 Supplier Base Analysis

As described before, the Dry goods supplier base consist of a limited number of suppliers where several suppliers stand for significant volumes. A majority of the Dry goods suppliers are long-term and ordered from regularly. Approximately 52% of the annual volumes of Dry goods are shipped in loose-loaded containers, which is the share of goods included in this study. The remaining volumes include mainly palletized containers, but also around two percent loaded with slip sheet. The volumes sent on slip sheet are sent from two small suppliers, sending the majority of their annual volumes on slip sheet. There are 41 suppliers in the loose-loaded segment. The 16 largest in terms of annual volume were studied further regarding their ability to change loading method to slip sheet. A chart over the 41 suppliers and their shipped volumes can be seen in Figure 8 below. The black bars are the 16 largest suppliers, that have been studied in detail. The 16 largest suppliers represent 83% of the annual volume of Dry goods received at ICA, making the investigation representative for a majority of the supplier base.

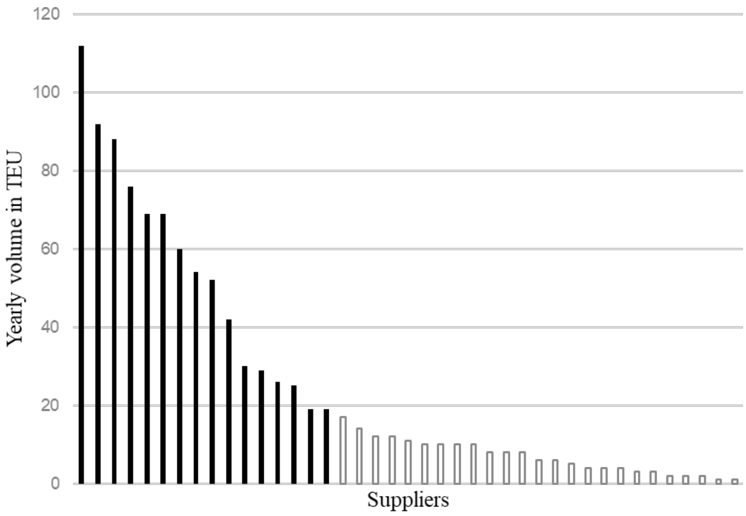


*Figure 8. A chart showing the suppliers in the loose-loaded Dry goods flow in descending order according to annual container volume.*

The 16 largest suppliers were inquired about the possibility to load containers with slip sheet and the effect that would have on the load factor. The survey sent to the suppliers can be seen in Appendix I. A response was received from all the suppliers contacted in the Dry goods segment. The majority, 75%, replied that they could ship on slip sheet and were already using the technology for other customers. Most of the suppliers with the proper technology in place stated that a change from loose-loaded to slip sheet could be made immediately. The other 25% either did not have the technology at all or shipped on slip sheets with other dimensions than the ones wanted by ICA. However, some of the suppliers not having the proper equipment at the moment was open to potential future implementation.

Three of the contacted suppliers that offered slip sheet explicitly stated that they charged no additional cost for loading the goods in the new way. Two suppliers stated that a conversion to slip sheet would be charged with an additional fee, ranging from 10 SEK per distribution box to 50 SEK per slip sheet. The information provided was only the first proposal from the suppliers. There is likely room to reduce the initial offer in the case of an implementation by negotiating the rate. For the suppliers that did not comment on any changes in the rate, it is likely that a mutual agreement must be negotiated. It is important to consider that there is a trade-off between the price and the quality of the slip sheet (Mulcahy, 1999). According to Big Bolts, the right quality of the slip sheet is essential for a successful outcome.

#### 5.1.2.3 Investment Requirements

The need for investments differs depending on the available technology and capacity at the node that will handle the goods. The warehouse Harbor Cargo in Gothenburg, that is receiving all containerized Dry goods, is already handling slip sheets today. However, only about two percent of the annual volume arrives on slip sheet. A push/pull attachment has been mounted on a forklift that is not used for any other operations in the warehouse, making it a dedicated resource for slip sheet handling. ICA is the only customer in the warehouse that utilizes the technology, so the capacity of the forklift and attachment does not have to be split with any other actors. As such, there is plenty of available capacity in terms of uptime. Even if the volume of goods arriving on slip sheet would significantly increase, there is available capacity in the equipment. An increase in volumes shipped on slip sheet that would exceed the available capacity is deemed unlikely. As a result, the investments required to utilize slip sheet at Harbor Cargo are non-existent.

#### 5.1.2.4 Impact on Annual Operating Costs

The savings in materials handling are derived from more efficient loading and unloading of containers, as expressed by Bouma (1980). Handling goods loaded on slip sheets is more time-efficient compared to manually handling the boxes since the slip sheets can be handled by a forklift and directly transferred to a pallet. The time required for unloading slip sheets is slightly longer than palletized goods, as more caution is required to grip the slip sheet correctly, but still significantly shorter than handling loose-loaded goods. The reduction in handling time follows the unit load principle proposed by Lumsden (2007) and the theories put forward by Spencer & Ebeling (2011) that highlight the economic benefit of handling unit loads rather than separate units. Since containers loaded with slip sheet requires less time for unloading than loose-loaded goods, ICA pays a lower rate at the external warehouse Harbor Cargo. The relative price difference between unloading loose-loaded containers and containers loaded on slip sheet can be seen in Table 3.

The load factor in each container will decrease when switching from loose-loaded to slip sheet, resulting in an increased number of shipments per year to maintain the same shipped volume. The reduced load factor for slip sheets can be derived from the load factor framework by Santén (2016). The shape and dimension of the packaging used, limits the load utilization efficiency that can be achieved (Pålsson et al., 2013). In the case of shipping loose-loaded goods, the load factor is influenced only by the interface between the distribution box dimensions and the container dimensions. When shipping goods on slip sheet, the load factor is dependent both on the interface between the distribution box dimensions and the slip sheet, and the interface between the slip sheet and the container. The interface between the distribution box and the slip sheet will be similar to the interface of the distribution box and a EUR-pallet. Typically, the load factor in the interface between a distribution box and a pallet is not 100% as the dimensions of the distribution box restrict the potential load factor.

When loose-loaded containers are shipped, the loss in load factor arises when the goods are palletized upon arrival at the receiving end. In the current setup, this means that the loss in load factor surfaces when the distribution boxes are stacked on pallets at Harbor Cargo. When shipping containers loaded on slip sheet, a loss in load factor surfaces already at the supplier, while loading the container. As expressed by Lumsden (2007), the interface between an ISO container and a EUR-pallet is poor. McDonald (2016) states that the maximum floor utilization of a 40-foot container is only about 85% when loaded with EUR-pallets. Since the slip sheets would have the same length and width of a EUR-pallet in ICA's flow, the same floor utilization is achieved. A better volume utilization is possible, but not certain when using slip sheet compared to pallets since the height of the slip sheet is a fraction of the height of a pallet. The excess height may be used to load additional goods. Both pallets and slip sheet require a gap of air above the top layer of goods to be able to maneuver the forklift, which is not needed for loose-loaded goods.

A transition to slip sheet would lead to a reduced need for man-hours also at the supplier end since the mechanical equipment enables fast loading (Sopack, n.d.-b). The increased efficiency in loading the container is similar to the improvements in the unloading. It was mentioned by some suppliers that the transfer to sending goods on slip sheet would incur an additional fee. The magnitude of the fee is subject to negotiation, and as such the factor has been excluded from the calculations for the impact on the annual operating costs, to avoid making conclusions based on uncertain input data.

The data regarding shipment volumes at ICA was structured according to orders, one order row representing one container being shipped. Each order row in the data file contained information about the shipment, such as supplier, container size, and estimated date of arrival. As a result of several factors, different data was available for each order row. One major factor was that much of the data handling is done manually and that data is lacking. Another factor was that the historical data available varied between different databases that were used in the project. The majority of information in the order rows were available from February 2019 to January 2020. However, a complementary file containing data about volumes received per order was only available for 12 months rolling. As a result, it was not possible to retrieve data about the shipping volumes for all order rows. The received volume for each order is registered in the warehouse when the goods are received.

Due to the difference in available data, a segmentation of the order rows was done for the calculation of the potential of slip sheet. For all suppliers, the current load factor in the loose-loaded containers could be derived from ICA's internal data about incoming shipment volumes. For the 16 largest suppliers, the load factor that would be achieved in the transition to slip sheet was established using the software Cape Pack. For the shipments already arriving on slip sheet, the internal data instead showed the actual load factor on slip sheet. A comparison between the current load factors on slip sheet and the theoretical ones from Cape Pack showed that the values were in line with each other, making the Cape Pack calculations reliable.

A comparison of the actual loose-loaded load factors and the Cape Pack load factors on slip sheet enabled detailed calculations about the savings potential and incurred costs for the 16 largest suppliers. A pattern in the deterioration of the load factor was identified and used for the remaining suppliers where only the current load factor was known. Below follow more detailed descriptions of the calculations for the two data segments, Complete data availability and Partial data availability. In the segment Complete data availability, the 16 largest suppliers are evaluated. In the segment Partial data availability, the potential of the remaining supplier base is evaluated.

##### *5.1.2.4.1 Complete Data Availability*

For this data set, it was possible to determine the load factor in a container both for slip sheet and loose-loading. The load factor for the two loading alternatives was calculated using the software Cape Pack. The calculations were made for one single item number at a time since containers with mixed item numbers were not possible to simulate in the program. In reality, there may be a single item number in the entire container or a mix of several item numbers. Consideration had to be taken to the fact that it was not possible to distinguish which item numbers a certain container contained, as the calculations would be much too detailed. Images from the software can be seen in Figure 4.

From Cape Pack, information was extracted regarding the number of distribution boxes that could be loaded in a container, either by shipping loose-loaded or on slip sheet. Since the volume was the constraining factor in all of the cases, the load factor was calculated with regard to the volume of a distribution box. By multiplying the distribution box volume and the number of distribution boxes in a loose-loaded container, putting it in relation to the maximum volume of a container, the load factor could be calculated as follows:

$$Load\ factor_{Loose-loaded} = \frac{Volume_{Distribution\ box} * Number\ of\ boxes_{Loose-loaded}}{Volume_{Container}}$$

Where $\text{Load factor}_{\text{Loose-loaded}}$ is the load factor in a loose-loaded container, $\text{Volume}_{\text{Distribution box}}$ is the volume of a single distribution box, $\text{Number of boxes}_{\text{Loose-loaded}}$ is the number of distribution boxes in a loose-loaded container retrieved from simulations in Cape Pack, and $\text{Volume}_{\text{Container}}$ is the maximum volume of an ISO container.

The loose-loaded load factor extracted from calculations in Cape Pack was theoretical. As described before, the actual load factor for the loose-loaded containers was also available, retrieved from ICA’s data about received volumes in the warehouses. When comparing the theoretical and actual load factor it was discovered that they did not have an exact match. However, the slight difference was expected since the theoretical calculations were based on one single item number in a container, and in reality, there are often several item numbers shipped together. The load factor comparison, therefore, worked as validation for using the theoretical Cape Pack calculations. The difference in the calculated and actual load factor was small and therefore it was considered appropriate to use the calculated load factor for the purpose of the project. Further validation of using Cape Pack was done when looking into the actual load factor in the containers loaded on slip sheet already today. Firstly, by comparing the actual load factor on slip sheet to the one calculated in Cape Pack, which were similar to each other. Secondly, by putting the actual load factor on slip sheet in relation to the loose loaded extracted from Cape Pack, which showed a similar pattern to the other load factor comparisons.

From the Cape pack calculations, the number of distribution boxes in a container loaded with slip sheet could be established. The relation between the number of distribution boxes in a loose-loaded container and one loaded on slip sheet was used to find to what degree the load factor would be affected when converting to slip sheet. The change in load factor was calculated in the equation

$$Remaining\ load\ factor = \frac{Number\ of\ boxes_{Slip\ sheet}}{Number\ of\ boxes_{Loose-loaded}}$$

Where the Remaining load factor is the share of the loose-loaded goods that remain when loading the container with slip sheet instead and Number of $boxes_{Slip\ sheet}$ is the number of distribution boxes in a container loaded with slip sheet retrieved from simulations in Cape Pack.

To calculate the resulting load factor on slip sheet, the equations for the loose-loaded load factor and the load factor reduction are combined as follows:

$$Load\ factor_{Slip\ sheet} = Load\ factor_{Loose-loaded} * Remaining\ load\ factor$$

Where Load $factor_{Slip\ sheet}$ is the load factor in a container loaded on slip sheet.

The calculations of slip sheet unit loads in Cape Pack could not be done for all item numbers in the assortment of the 16 suppliers, as it required extensive manual work. The item numbers calculated in Cape Pack were selected carefully to cover a wide range of distribution box attributes. For example, load factors for item numbers with different dimensions and shapes were calculated. For suppliers with a homogeneous assortment, such as a supplier of canned goods, a representative item was used to determine the load factor for the complete assortment. For suppliers with several item numbers with distinct measures, such as a supplier of condiments in varying sizes, the load factor for both loose-loading and slip sheet was determined by weighing the load factor of some different item numbers for each loading practice. The load factor per item number was weighted depending on the item numbers share of the annual volume at the supplier. An example of the weighted calculations for a fictitious supplier X, shipping loose-loaded goods, can be seen below in Table 6. The load factor of items A, B, and C are weighted in relation to the share of the annual volume at the supplier. Since most suppliers have a relatively homogenous assortment, this was thought to have marginal effects on the total cost implications. The selection of item numbers also considered the annual item number volumes, to cover as large a share of the shipped volumes as possible. Approximately 50% of the total annual volume was covered by calculations in Cape Pack.

*Table 6. An example of how the weighted load factor was determined for the fictitious supplier X.*

| **Item** | **Share of Annual Volume** | **Load Factor Loose-Loading** |
|---|---|---|
| Item A | 40% | 0,8 |
| Item B | 25% | 0,75 |
| Item C | 35% | 0,85 |
| **Total** | **100%** | **0,805** |

The resulting calculated load factors for the 16 largest suppliers for the two loading practices are summarized in Table 7 below. The load factor for loose-loaded goods is consistently higher than the load factor for slip sheet.

*Table 7. The calculated load factor for the 16 largest suppliers.*

| **Supplier** | **Calculated Load Factor Loose-Loaded** | **Calculated Load Factor Slip Sheet** |
|---|---|---|
| Tuna Supplier 1 | 84% | 55% |
| Asian Foods Supplier 1 | 73% | 53% |
| Dried Fruits Supplier 1 | 92% | 55% |
| Rice Supplier 1 | 76% | 57% |
| Plastic Bag Supplier 1 | 89% | 51% |
| Rice Supplier 2 | 76% | 57% |
| Asian Foods Supplier 2 | 92% | 51% |
| Canned Foods Supplier 1 | 81% | 63% |
| Tuna Supplier 2 | 84% | 55% |
| Canned Foods Supplier 2 | 82% | 64% |
| Canned Foods Supplier 3 | 53% | 34% |
| Dried Fruits Supplier 2 | 82% | 66% |
| Canned Foods Supplier 4 | 75% | 60% |
| Asian Foods Supplier 3 | 77% | 63% |
| Canned Foods Supplier 5 | 79% | 66% |
| Dried Fruits Supplier 3 | 95% | 73% |

For the Dry goods flow, the savings potential per container in the receiving operations is derived from the price agreement with Harbor Cargo. The loose-loaded containers and the containers loaded on slip sheet are charged differently, and the savings potential is the difference between the two. A relation between the unloading rates can be seen in Table 3. Containers with more than 3000 distribution boxes are charged with an additional fee, resulting in even larger savings potential for some shipments. The additional fee is added since the time for unloading a container is related to the number of consignments inside.

By assuming that ICA's volume from the previous year as a representative value for the future volumes going through Harbor Cargo, the annual volume of goods arriving loose-loaded could be determined. Each of the loose-loaded containers will generate a reduction in handling costs for ICA if they are instead sent to Harbor Cargo on slip sheet. The total annual volume of goods should remain constant regardless of which shipping method is applied, as the customer demand will not be influenced in the project. As such, additional shipments must be sent to compensate for the deterioration in the load factor. The costs for shipping and handling the additional containers have to be deducted to see the annual financial impact from a transition to slip sheet. The annual container volumes, the type of container, as well as the cost of shipping a container was known for each order row. The annual shipping volumes were therefore aggregated to a total volume of containers per supplier. Calculating the increased number of shipments requires identification of the load factor utilization of loose-loaded and putting it in comparison to the load factor using slip sheet. Putting the expressions for the two shipping volumes as equal leads to the first formula being:

$$TEU_{Loose-loaded} * Load\ factor_{Loose-loaded} = TEU_{Slip\ sheet} * Load\ factor_{Slip\ sheet}$$

Where $TEU_{Loose\text{-}loaded}$ and $TEU_{Slip\ sheet}$ is the number of containers required for shipping the annual volume of goods loose-loaded or on slip sheet and Load $factor_{Loose\text{-}loaded}$ and Load $factor_{Slip\ sheet}$ are the load factors for the different shipping methods respectively. By combining data from ICA regarding annual volumes and data from Cape Pack related to the load factor, the number of shipments required for shipping the same amount of goods on slip sheet was calculated. The financial impact of slip sheet was obtained by subtracting the cost for shipping and receiving the additional containers from the savings incurred in the receiving operations.

The resulting equation can be expressed as:

$$Potential = Savings\ MH_{Harbor\ Cargo} - Cost\ MH_{Harbor\ Cargo} - Cost\ shipping$$

Where Savings $MH_{Harbor\ Cargo}$ is the savings in materials handling (MH) from sending the goods on slip sheet instead of loose-loaded, Cost $MH_{Harbor\ Cargo}$ is the additional cost for handling the extra containers, and Cost shipping is the cost for shipping the extra containers.

Each factor in the equation can be expanded as follows:

$$Savings\ MH_{Harbor\ Cargo} = TEU_{Loose-loaded} * (Rate_{Loose-loaded} - Rate_{Slip\ sheet})$$

$$Cost\ MH_{Harbor\ Cargo} = (TEU_{Slip\ sheet} - TEU_{Loose-loaded}) * Rate_{Slip\ sheet}$$

$$Cost\ shipping = \left(TEU_{Slip\ sheet} - TEU_{Loose-loaded}\right) * Shipping\ cost\ per\ container$$

Where $TEU_{Loose\text{-}loaded}$ and $TEU_{Slip\ sheet}$ is the number of containers needed for shipping the annual volume loose-loaded respectively on slip sheet, $Rate_{Loose\text{-}loaded}$ and $Rate_{Slip\ sheet}$ is the unloading rate at Harbor Cargo that is charged for handling one of ICA's containers, and Shipping cost per container is the freight cost for shipping a container from a specific supplier. In Table 8 below, the result from calculating the potential for the 16 largest suppliers studied in this project is presented.

*Table 8. The potential of slip sheet for the 16 largest suppliers studied in this project.*

| **Supplier** | **Load Factor Reduction** | **Potential** |
|---|---|---|
| Tuna Supplier 1 | 35% | −446 000 SEK |
| Asian Foods Supplier 1 | 26% | −315 000 SEK |
| Dried Fruits Supplier 1 | 40% | −272 000 SEK |
| Rice Supplier 1 | 25% | −252 000 SEK |
| Plastic Bag Supplier 1 | 43% | −197 000 SEK |
| Rice Supplier 2 | 25% | −189 000 SEK |
| Asian Foods Supplier 2 | 45% | −166 000 SEK |
| Canned Foods Supplier 1 | 23% | −158 000 SEK |
| Tuna Supplier 2 | 35% | −125 000 SEK |
| Canned Foods Supplier 2 | 23% | −89 000 SEK |
| Canned Foods Supplier 3 | 35% | −78 000 SEK |
| Dried Fruits Supplier 2 | 20% | −55 000 SEK |
| Canned Foods Supplier 4 | 20% | −43 000 SEK |
| Asian Foods Supplier 3 | 17% | −42 000 SEK |
| Canned Foods Supplier 5 | 16% | −11 000 SEK |
| Dried Fruits Supplier 3 | 23% | −5 000 SEK |
| **Total** | | **-2 443 000 SEK** |

As can be seen in Table 8, the decrease in load factor is significant when shipping on slip sheet instead of loose-loaded, which is well-aligned with the theories of for example Lumsden (2007) and McDonald (2016). It is also aligned with the learnings from the workshop with Home Decor. The reduction in load factor ranges between 16 and 45%, which derives from that the load factor is both dependent on the slip sheet in relation to the container size, as well as the distribution box dimensions in relation to the slip sheet dimensions and maximum pallet height. As mentioned before, the interface between a slip sheet and a container is not favorable, creating an immediate load factor reduction of 15%. In addition to this, the load factor on the pallet causes a further reduction between 2 and 26%.

The maximum dimensions of a unit load on slip sheet must be within the maximum dimensions of a palletized unit load, which is 1200 * 800 * 1250. The load factor on the pallet is dependent on the stack pattern that can be generated with the distribution box size at hand. Currently, ICA considers many aspects when designing the distribution box size. The primary focus is not to achieve a high load factor on the pallet, but rather to combine the aspects of product design and available store shelf space, as well as the supplier capabilities. Since ICA is not the main customer of many of their suppliers, they sometimes have limited ability to affect the dimensions of the distribution box unless suggested by the supplier. Since the majority of the suppliers considered in this project are located in Asia, it is not unlikely that a partial explanation to the poor load factor utilization on EUR-pallet sized slip sheets, visible in Table 7, can be derived from optimization to 1200 * 1000 pallets that are more common in the region. The habit of designing the distribution box size according to several factors may be the explanation for the large variation in load factor for the containers loaded on slip sheet. In the loose-loaded containers, the load factor is only determined by the dimensions of the distribution box. The distribution boxes seem to be well adapted to be loaded into the containers, which can be seen in the high load factors for loose-loaded in Table 7. As explained by Bortfelt and Wäscher (2013), all constraints must be considered optimizing the load factor of a container. A load factor close to 100% can be achieved in terms of both floor utilization and cube used unless for example the weight limit of the container is reached before the volume of the container is filled.

To evaluate the attractiveness of the project, it was intended to use a payback period method. The payback period method is used to determine the time required for a project's earnings to equal the project investment (Remer & Nieto, 1995b). The above calculations add up to a total negative potential of -2,443 million SEK per year, indicating that there are no earnings to be made. Should the numbers be put into the equation for determining the payback time, the time would extend into infinity. In order for a project to be considered attractive, the payback period must be equal to or shorter than the economic life of the investment, which is definitely not the case for this segment of the calculations.

##### *5.1.2.4.2 Partial Data Availability*

For this data set, the suppliers' load factor was known only for the current shipping method, which is loose-loaded. The load factor was derived by putting the data about the received volumes in relation to the maximum capacity of a container. The annual volumes and the freight cost per container were known for each supplier. However, the load factor on slip sheet was not known, making it impossible to do the same calculations as for the segment with complete data availability. Instead of calculating the potential for each supplier, the breakeven where the savings potential was zero was calculated. The calculations were based on the that the suppliers' total annual loose-loaded volume was to be shipped on slip sheet instead. By identifying the annual number of shipments where the potential was zero, a minimum required load factor could be defined. It could then be concluded whether a supplier had savings potential or not from changing to slip sheet, depending on if it was deemed likely that the minimum load factor could be achieved. Two formulas were used for the data set with partial availability. The first equation illustrates the scenario when the savings in reduced materials handling is equal to the cost of handling and shipping additional containers. The equation used to determine how many TEUs loaded with slip sheet that would result in a total cost impact of zero while keeping the volume of goods constant is:

$$TEU_{Slip\ sheet} = \frac{TEU_{Loose-loaded} * (Shipping + Rate_{Loose-loaded})}{(Shipping + Rate_{Slip\ sheet})}$$

where $TEU_{Slip\ sheet}$ is the annual volume of shipped containers on slip sheet, $TEU_{Loose\text{-}loaded}$ is the annual volume of loose-loaded containers, Shipping + $Rate_{Loose\text{-}loaded}$ and Shipping + $Rate_{Slip\ sheet}$ respectively are the costs for freight and receiving operations per container.

The second equation, used to identify the load factor required in the slip sheet containers to ship the same amount of goods as in the loose-loaded flow with a savings potential of zero, is:

$$Zero\text{-}\ potential\ load\ factor_{Slip\ sheet} = \frac{TEU_{Loose-loaded} * Load\ factor_{Loose-loaded}}{TEU_{Slip\ sheet}}$$

where Zero-potential load $factor_{Slip\ sheet}$ is the calculated required load factor to achieve no potential in the transition to slip sheet and Load $factor_{Loose\text{-}loaded}$ is the current load factor in the loose-loaded containers.

The zero-potential load factor is then put in relation to the load factor in a loose-loaded container in another equation that identifies the allowed reduction in load factor:

$$Zero\text{-}\ potential\ load\ factor\ reduction = 1 - \frac{Zero\text{-}\ potential\ load\ factor_{Slip\ sheet}}{Load\ factor_{Loose-loaded}}$$

Where the Zero-potential load factor reduction shall be interpreted as the maximum allowed deterioration of the load factor for slip sheet in comparison to loose-loaded, or the point where there is no change in the annual operating cost for transporting and handling the goods. The zero-potential load factor reduction is then put in comparison to the findings about actual load factor deterioration observed in the segment with complete data availability. It was deemed likely that the actual reduction in load factor for the segment with partial data availability would be similar to the deterioration in load factor for the segment with complete data availability. If the actual deterioration is less than the zero-potential load factor reduction, a positive result would be generated for the supplier. Following the same logic, if the actual deterioration is larger than the zero-potential load factor reduction, the outcome of transferring the supplier to slip sheet would be negative. The calculated zero-potential load factor deterioration for the suppliers in the data set with partial data availability can be seen in Table 9.

*Table 9. The calculated Zero-potential load factor.*

| **Supplier** | **Zero-Potential Load Factor Reduction 20-Foot Container** | **Zero-Potential Load Factor Reduction 40-Foot Container** |
|---|---|---|
| Supplier 16 | 12% | |
| Supplier 17 | | 21% |
| Supplier 18 | | 23% |
| Supplier 19 | 12% | |
| Supplier 20 | | 14% |
| Supplier 21 | 10% | |
| Supplier 22 | 11% | |
| Supplier 23 | 12% | |
| Supplier 24 | | 16% |
| Supplier 25 | 10% | |
| Supplier 26 | 14% | |
| Supplier 27 | 9% | |
| Supplier 28 | 12% | |
| Supplier 29 | 10% | |
| Supplier 30 | 7% | |
| Supplier 31 | | 16% |
| Supplier 32 | 11% | |
| Supplier 33 | 10% | |
| Supplier 34 | 10% | |
| Supplier 35 | 9% | |
| Supplier 36 | 12% | |
| Supplier 37 | 10% | |
| Supplier 38 | 7% | 14% |
| Supplier 39 | 10% | |

The zero-potential load factor reduction for the goods shipped in 20-foot containers is ranging between 7 and 14%. The corresponding factor for 40-foot containers is ranging between 14 and 23%.

An explanation as to why the zero-potential load factor reduction for 40-foot containers is seemingly higher may be that the freight rate for a 40-foot container is not twice the rate of a 20-foot container, but slightly less. The same non-linear relation is found in the rate of unloading the container at Harbor Cargo. 40-foot containers are not two times as expensive to empty, and as a result, there are slightly larger savings to be made for the 40-foot flows which, visible in the higher zero-potential load factor reduction. The deterioration of the load factor from the segment with complete data availability ranged between 16 and 45%. The same pattern was shown for the goods already arriving on slip sheet. Applying the pattern of deterioration to this data segment, indicates that a positive impact from transferring the suppliers with a zero-potential load factor reduction of above 16% might exist. This means that Supplier 17 and Supplier 18 both could generate annual savings if the actual deterioration is less than 21% and 23% respectively. For the remaining suppliers, the zero-potential load factor reduction is smaller than or equal to the minimum observed deterioration of 16%, making it highly unlikely to derive any positive impact in a transition to slip sheet.

The possibility of converting Supplier 17 and Supplier 18 to slip sheet was further investigated. It appeared that both Supplier 17 and Supplier 18 had assortments that corresponded well to Canned Foods supplier 3 from the segment with complete data availability. As such, the actual deterioration in load factor for Supplier 17 and Supplier 18 is assumed to be similar to the deterioration for Canned Foods supplier 3, which was 35%. Such deterioration is much larger than the zero-potential load factor reduction of 21% and 23% for the two suppliers respectively. As such, there is no potential to achieve savings in transferring any of the suppliers in the segment with partial data availability. Following the same logic as for the segment with complete data availability, the payback period would extend into infinity if the suppliers with a negative impact on the annual operating costs would be transferred to slip sheet. Since the volume per supplier in this segment is smaller in comparison to the segment with complete data availability, it could also be argued that more effort would be required to get the slip sheet operations functioning well, which would further increase the cost of the project.

#### 5.1.2.5 Sensitivity Analysis

The calculations of the potential showed that a conversion to slip sheet was not favorable from a financial perspective. In order to make a robust recommendation and to assess the validity of the result, a sensitivity analysis was performed. As there is uncertainty about how several of the ingoing factors will evolve in the future, the sensitivity analysis was of great importance (Lamboni, 2018). In accordance with Sheposh (2019), the sensitivity analysis was executed by changing some of the underlying variables to see how the result was affected. Since there were many uncertainties, the first sensitivity analysis method described by Wolters and Mareschal (1995) was applied in this research. Three different factors were changed in order to identify how much the result was affected; the cost for shipping containers, the cost for using the external warehouse Harbor Cargo, and the load factor.

The first scenario evaluated was a decrease in the freight cost for shipping containers. Two different cases were calculated, one where the shipping cost decreased by 20% and one where it was reduced by 50%. The results from the calculations can be seen in Table 10 below.

*Table 10. The result from changing the underlying factor about the cost for shipping.*

| | **Shipping Cost -20%** | **Shipping Cost -50%** |
|---|---|---|
| Result | - 1 738 000 SEK | - 642 000 SEK |

In the detailed calculations, it can be seen that one supplier case turns positive at a decrease of 20%, and five cases turn positive at a 50% decrease. Concluded from this is that overall, slip sheet is still not favorable if the cost for shipping would decrease by 50%. Relative to the other ingoing variables, the cost for shipping is the one with the highest magnitude. Changing this variable hence affects the result considerably. However, a decrease of 50% or more is drastic and not likely to happen, a change in this variable will therefore not affect the recommendation.

The second scenario changed in the sensitivity analysis was the cost for using the external warehouse Harbor Cargo. The unloading rate from Harbor Cargo may be renegotiated in the future, consequently, there is uncertainty in the contracted agreement. An increase in the cost for Harbor Cargo was therefore chosen as a variable to change, first by 50% and as a second case by 100%. The results from changing the cost for the external warehouse Harbor Cargo can be seen in Table 11.

*Table 11. The result from changing the underlying factor about the price agreement with Harbor Cargo.*

| | **Unloading Rate Harbor Cargo +50%** | **Unloading Rate Harbor Cargo 100%** |
|---|---|---|
| Result | - 1 656 000 SEK | - 829 000 SEK |

When the rate is increased by 50%, the results for three of the suppliers turn positive. When the rate is increased by 100%, seven suppliers have a positive outcome. Since even a double in the rate does not affect the overall outcome, it can be concluded that the cost for Harbor Cargo has a relatively small impact on the result. Overall, the potential of slip sheet is negative in this scenario as well, indicating that changes in this variable do not affect the recommendation either. It appears that the shipping rates, changed in the first scenario, had a larger impact on the bottom-line result than the changes in the price agreement with Harbor Cargo.

The third scenario relates to changes in the load factor. As described in the previous section about the impact on annual operating costs, the reduction in load factor is the main driver of additional costs, and the primary reason that makes slip sheet unattractive. If the load factor could be improved when using slip sheet, the need for shipping extra containers could be decreased, and thereby the potential would increase. The load factor could be enhanced by improving either the packing efficiency, loading efficiency, or booking efficiency as expressed in the Load factor framework by Santén (2016). The packaging efficiency is affected by changing the design of the product or the distribution box, to utilize the space of the box in a better way. The loading efficiency expresses how well the distribution box can be formed into unit loads. The loading efficiency can be affected by changing the distribution box dimension or changing the unit load. The booking efficiency expresses how well the booked capacity is utilized. The booking capacity is managed by the supplier that is responsible for filling the container, and as such, it is out of the hands of ICA to determine the booking efficiency. Pallets and ISO containers are not adapted to each other, as described by Lumsden (2007), which can also be seen in the conversion between loose-loaded and slip sheet. According to McDonald (2016), the interface between EUR-pallet measures and a 40-foot ISO container utilizes the floor area to 85%. Since ICA uses EUR-pallet measures, 85% is the theoretically highest load factor that could be achieved without changing unit loads currently used.

*Table 12. The result from changing the underlying factor about the load factor in the containers.*

| | **Load Factor 85%** | **Load Factor 90%** |
|---|---|---|
| Result | - 393 000 SEK | 235 000 SEK |

The outcome of having a fixed load factor at 85% can be seen in Table 12. Three of the 16 suppliers have a positive outcome. Reaching this load factor would require a 100% load factor on the pallet, which is not the case today. Following the theories put forward by Pålsson et al. (2013), a load factor close to 100% could be reached if the distribution boxes are optimized to the EUR-pallet sizes. Reaching a 100% load factor on the slip sheet is however not likely since suppliers in various continents have different pallet standards (iGPS, 2018). According to McDonald (2016), optimizing for different pallet measures creates challenges in the supply chain, something that could make it difficult for ICA to get everyone in their network to optimize the boxes according to their needs. Success in achieving the maximum load factor of 85% on the slip sheets would however still not make slip sheet attractive.

A second case investigated was a load factor of 90%. In Table 12, it can be seen how slip sheet at a 90% load factor, is an attractive solution. There is savings potential for all suppliers except one. Utilizing the container volume to 90% is however not possible with today's setup with EUR-pallets measures and ISO containers. A change in the unit load is required, which could improve the loading efficiency. Changing any of these standards to better utilize the container, which is essential for efficient operations according to Bortfeldt and Wäscher (2013), is not a probable scenario. On the one hand, the container was invented in 1956 (Lumsden, 2007) and is a global standard used for long-distance freight. On the other hand, pallets are the most popular system for shipping unitized loads (Spencer & Ebeling, 2011). ICA is using EUR-pallet, which is the most widely used pallet dimensions in the world (Twede et al., 2007). To conclude, at a load factor of 90% slip sheet is an attractive solution. However, reaching 90% is not technically possible with the unit loads used today and they are not likely to be changed as they are established standards used worldwide. ICA must further consider that many different transport modes are used in their supply chain. All deliveries from the central warehouses to the distribution units and some deliveries to the stores are on EUR-pallet in semi-trailers, which are a good fit (Access Logistics, n.d.). All pallet racking in the warehouses is furthermore designed to fit EUR-pallets. Selecting other unit loads would be a costly and difficult project, that may lead to sub-optimization of other flows in the supply chain.

*Table 13. A summary of the sensitivity analysis.*

| **Change** | **Effect on the Recommendation** |
|---|---|
| Shipping cost -20% | No effect, only one supplier turns positive |
| Shipping cost -50% | Limited effect, five suppliers turn positive |
| Unloading rate +50% | No effect, three suppliers turn positive |
| Unloading rate +100% | Limited effect, seven cases turn positive |
| Load factor reaches 85% | Limited effect, three suppliers turn positive |
| Load factor reaches 90% | Change in recommendation, 15 suppliers turn positive |

In Table 13, a summary of the sensitivity analysis can be seen and how the factors affect the recommendation. The three underlying factors that were changed; the shipping cost, the price agreement with Harbor Cargo, and the load factor, are compared to the alternative of loose-loading. In a fourth scenario, loose-loading could stop being an alternative for loading containers. Already today there are restrictions for manual labor regarding the maximum weight that can be handled without supporting equipment (Arbetsmiljöverket, 2012). These types of restrictions could be extended to include even more aspects of manual labor in the future. Considering that Global Furniture decided to stop loose-loading about 30 years ago because of the extensive manual labor that it requires, it could also be the case for ICA further on. When moving away from loose-loading, it is clear that the load factor will be affected, and the challenge will be to minimize the negative effects as much as possible. One way to keep the load factor as high as possible is to maximize the volume utilization on the pallet or slip sheet. When choosing unit load, it is not obvious whether a pallet or slip sheet will be most beneficial. Slip sheet is more favorable if more goods can be loaded in the container than if pallets are used, and that depends on the distribution box dimensions at hand. However, as long as loose-loading is still an available loading option, it will be the most favorable alternative from an economical point of view.

#### 5.1.2.6 Concluding Remarks

To summarize the insights and findings from the Dry goods flow, it can be stated that the preconditions in terms of contextual factors and product characteristics are promising. The assortment and product dimensions are changed rarely, which provides the possibility to create accurate stack patterns and keep them up to date. The annual container volumes are concentrated to a relatively small supplier base, which means that effort could be targeted to maximize the outcome of a transition. The slip sheet technology is seemingly widespread in the existing supplier base, and amongst those who did not yet have the technology available, interest was expressed to implement it further into the future. This indicates that the availability of the equipment and know-how at the supplier side would not restrict a rollout of slip sheet at ICA. The investment requirements for ICA are non-existent in the current setup where the goods are unloaded at the external warehouse Harbor Cargo. All necessary equipment and operational skills are in place, and there is excess capacity to be utilized.

Despite that the surrounding factors seem to be speaking in favor of a transition to slip sheet, there is a major obstacle. With the currently used unit loads, EUR-pallets and ISO containers, a large deterioration in the load factor is inevitable when the goods are loaded on the EUR-pallet-sized slip sheets in the container. The reduction in load factor leads to a significant increase in the number of shipments per year to receive the same amount of goods. The cost of shipping and handling the additional container exceeds the savings generated in the materials handling operations. As a result, a transition to slip sheet would increase the annual operating costs significantly. No matter if the underlying factors are varied and examined further the result becomes consistently negative. The negative potential, in turn, results in an infinitely long payback time for the project. The additional costs of unitizing the loose-loaded goods become larger than the associated savings in materials handling, which means no unitizing should be done according to the principles of Lumsden (2007). Slip sheet is not an attractive solution for the Dry goods segment. In Table 14 below, the characteristics of the Dry goods segment can be seen next to the ones for the Non food segment. The contextual factors of the Non food segment all contribute to a poor environment for slip sheet. The contextual factors for the Dry goods present good preconditions for applying slip sheet.

*Table 14. A summary of the contextual factors for the Non food and the Dry goods segment.*

| **Contextual Factor** | **Non Food** | **Dry Goods** |
|---|---|---|
| Assortment | Wide | Small |
| Seasonality | High | Low |
| Product characteristics | Heterogeneous and Bulky | Homogeneous and manageable |
| Distribution box dimensions | Frequently changing | Rarely changing |
| Compliance with agreed distribution box dimensions | Poor | Good |
| Stack pattern | Difficult to maintain | Easy to maintain |
| Order behavior | Order according to demand | Order to fill container |
| Order volume | Low | High |
| Flow of goods | >45 cbm: From supplier directly to ICA<br><45 cbm: From supplier, via consolidation terminal to ICA | From supplier directly to ICA |
| Supplier relationships | Short term | Long term |
| Supplier base | Wide | Small |
| Slip sheet compatibility | Poor | Good |

## 5.2 Additional Effects of an Implementation

In addition to finding and evaluating the contextual factors, doing a supplier base analysis, compiling the investment requirements, and investigating the impact on annual operating costs, several other effects must be evaluated in the case of implementing slip sheet. Some of the effects that are considered important are brought up for analysis below.

Mĺkva et al. (2016) argue that more standardized operations have less variation. The reduced variation could improve resource utilization, following the logic of Kingman's equation (Modig & Åhlström, 2015). According to Mĺkva et al. (2016), standardization of processes also enables working with continuous improvement, which could be an advantage for ICA. It is more difficult to standardize the method for emptying a loose-loaded container, as the time required is highly dependent on the content, such as the number of consignments inside. This is visible in the receiving operations at ICA where the time for handling loose-loaded containers varies more than the handling of palletized ones. The average time for emptying a loose-loaded container at ICA is estimated to be around nine to twelve hours. There are also reported cases of unloading operations requiring much more time, contributing to an even greater variation in the handling operations. If the goods are palletized, a forklift can be used to handle the unit loads and the operations are more standardized. The standardization of the operations is visible in the time required for emptying palletized containers, which is estimated to be about one and a half to two hours. Since the handling of slip sheet is much like handling of pallets, the variation in the operations would decrease when converting from loose-loaded to slip sheet. Further, Tompkins (1994) states that there is an increase in productivity from improving methods where human labor is involved, which would be the case for ICA when changing from loose-loaded to slip sheet.

According to Gu et al. (2007), a challenge in warehouse operations is the allocation of resources, such as how much space and staff that is required for each operation. Implementation of slip sheet would require less labor and time in loading and unloading compared to loose-loading (Castetter, 2019). A potential positive consequence from establishing slip sheet at ICA would, therefore, be the opportunity for more predictable and accurate resource planning. Planning the staff more precisely can also contribute to avoiding the issues brought up by Tompkins (1994) related to either having too much or too little staff. The resource utilization can also be improved without prolonging the throughput time if the variation is reduced as explained in Kingman's equation (Modig & Åhlström, 2015). Less time required for unloading containers also results in shorter turnaround time at the warehouse gate, increasing resource utilization, and creating an opportunity for new containers to arrive. The lead time of the delivery is also shortened by a few hours. Although the containers have a shorter turnaround time at the receiving gate, the cost of container rent is not affected since the rent is paid daily and not per hour. The lead time of the containers is often about six weeks and reducing it by a few hours has a marginal impact.

Handling all the goods manually is a time consuming and strenuous work. Standardizing the operations by making it possible to handle the slip sheets with a forklift, will hence improve the working conditions significantly for the operators. Improved conditions and ergonomics can, in turn, reduce accidents and further reduce the staff turnover and the need for sick leaves, resulting in decreased employee costs. The Swedish Work Environment authority is continuously working to improve the working conditions in warehouses by for example establishing restrictions related to how much manual work that is allowed. One restriction is that it is not recommended to manually lift items heavier than 15 kilograms (Arbetsmiljöverket, 2020). Attention has to be paid in the future to what further restrictions might be introduced, that restrict manual labor. Slip sheet could be the solution for ICA to completely move away from manual labor in the good receiving operations at the same time as improving the work environment in the warehouses.

Another factor that ICA has to pay attention to is the growth in salary in the countries where the suppliers are situated, as a result of a relatively higher economic development. Many of the suppliers are located in Asia, where the salary growth is rapid as compared to for example Europe (Human Resources Online, 2019). The salary increase makes loose-loading a more unattractive solution since the loose-loading is very time consuming and an increase in salary might affect the pricing from the suppliers. A way of handling the goods more efficiently, for example by slip sheet, will hence be desired from both the supplier and ICA.

Johnson (1980) describes how slip sheet can enable a secure and stable loading of goods into the containers by placing the unit loads close together with a lower center of gravity, resulting in less damaged goods. This is something that was confirmed by Big Bolts, stating that they had experienced less damaged goods after changing unit load from pallet to slip sheet. Accordingly, the perception from Harbor Cargo was that goods arriving on slip sheet were less exposed to damages compared to the ones arriving loose-loaded, resulting in a cost reduction for handling damaged goods. In addition to this, it is important to consider the importance of proper training of the employees to handle the slip sheets correctly, not damaging the goods after arriving at the warehouses (Johnson, 1980). Having proper training was brought up by both Harbor Cargo and Big Bolts as a key factor for succeeding with slip sheet.

When choosing which unit load to use, it is important to consider the compatibility with automation (IFCO Systems, 2017). Slip sheet cannot alone be used in automated systems since the sheet is not rigid enough to keep the unit load intact in a storage rack (Johnson, 1980). However, goods loaded on slip sheet is possible to handle with a forklift, which will increase the degree of mechanization. Kay (2012) argues that mechanization of operations should always be made if it is viable to increase the operating efficiency, predictability, and eliminate repetitive and hazardous manual labor. However, it is important to remember that slip sheet is not suitable for all kind of products, hence the return on the needed investments also have to be considered (Castetter, 2019). This is the case for slip sheet, where a special forklift attachment is needed (Bouma & Shaffer, 1982). When Global Furniture decided to completely move away from loose-loaded shipments, one reason was for the non-existing compatibility with automation. By changing to slip sheet and increase the mechanization, ICA could be ready to handle more automation in the warehouses at the same time as improving the operational efficiency and eliminating repetitive manual labor.

Making the warehouse operations more ready for increased automation follows the warehousing trends presented by McCrea (2019). An observation from Harbor Cargo was that more customers were asking for slip sheet as a way of loading goods, speaking for an interest in the industry to make the unloading operations more efficient. Additionally, the workshop with Home Decor showed that interest for slip sheet exists in the industry. An increase in companies using slip sheet would make the technology more widely used, which could be an advantage when negotiating with suppliers. ICA is a relatively small player in the industry, which could imply limited negotiation power when discussing rate changes for the loading method or talking to suppliers not using the technology. It is thereby important to take a wider perspective and consider what possibilities ICA has in affecting their supply network.

A further aspect that must be considered is the environmental aspects of changing unit load. As presented earlier, the new setup would result in an increase of containers being shipped to

Warehouse 1 due to a lower load factor, hence the environmental impact will increase. This is on the contrary to Santén (2016), who mentions the importance of reaching a higher load factor to reduce the environmental impact. By monitoring the environmental performance at ICA, it can be included as a factor when making decisions affecting the environmental sustainability of the shipping overall. In addition to the shipments, it is essential to consider the environmental impact of the slip sheet itself. Slip sheets are used one time and then recycled, not creating a return flow back to the supplier, an important aspect to consider according to Lumsden (2007). Choosing a sheet made out of carton board, which is the case for both Harbor Cargo and Big Bolts, makes recycling easy.

Aside from the occasional deliveries on slip sheet to General Cargo, all goods being transported into ICA's warehouses arrive either on a pallet or loose-loaded. When arriving loaded on a pallet, the EUR-pallet is the most widely used since a lot of goods are transported to ICA from within Europe in a semi-trailer. The EUR-pallet and semi-trailer are well adapted to each other, making it an efficient unit load solution (Access Logistics, n.d.). In case of a wider implementation of slip sheet, consideration also has to be made to the interface with the already existing infrastructure and if it is wise to implement one additional unit load. Especially since slip sheet requires the receiving nodes to have special equipment. However, slip sheet is well compatible with the EUR-pallet since the slip sheet is placed directly onto a pallet at arrival in the warehouse, making the receiving operations more efficient.

# 6 Discussion

In this chapter, the results of the analysis are discussed. The chapter is split into three sections. In the first section, the results will be discussed in comparison to the research questions and the purpose of the research. The three research questions are discussed respectively, before the fulfillment of the purpose of the thesis is discussed. The second section brings up a general discussion about the quality of the research and the transferability of the results. The third and final section presents ideas and suggestions for future research.

## 6.1 Discussion of Results

This section of the discussion is divided into four parts, where the three first parts deal with each of the research questions respectively. First, the result from the current state mapping will be discussed by comparing the characteristics of the Non food and the Dry goods flow. Second, the result from the potential analysis regarding a conversion to slip sheet and its immediate effects will be discussed, including an investigation of the robustness of the result and an outlook of future challenges for ICA. In the third part, the analysis of the additional effects related to slip sheet will be reviewed. Fourth and finally, the overall fulfillment of the purpose of the thesis is discussed.

### 6.1.1 The Current Flow of Loose-Loaded Containerized Goods

The current state description of the goods flow to ICA was created based on historical data from the previous year. The annual volume was assumed to remain constant in the near future. The assumption of a constant annual volume was made by observing annual volumes further back, indicating that there is no large growth or decline in the volumes being shipped.

Distinct differences between the Non food and Dry goods flow were detected in the mapping of the current state. The goods are designed to arrive at different receiving nodes in the supply chain. The fact that the Dry goods arrive at the external warehouse Harbor Cargo and the Non food goods arrive at ICA's internal warehouses is a decision made by ICA, and not based on any specific requirements or preconditions. As such, the flows could be redirected in the future if desired. If slip sheet would become attractive for some Non food goods it could, for example, be considered to send the goods through Harbor Cargo on slip sheet instead of investing in equipment at the internal warehouses.

The supplier base of the Non food goods segment is much wider than the supplier base for the Dry goods. The product characteristics also differ between the segments. The Dry goods are mainly uniform and easily palletized, in contrast to the Non food goods that are often bulky and large. The Non food goods are characterized by strong seasonality, since many of the items are related to holidays or particular seasonal activities, such as Christmas ornaments or barbeques. There is little possibility to reduce the seasonal variance as it is a distinct feature of the segment itself. The seasonal variance and frequent changes in the assortment, in turn, makes it more difficult to keep and maintain supplier relationships over time.

Another difference between the two segments is the order behavior. Non food goods are always ordered according to actual demand, and Dry goods are ordered in volumes that fill the containers already at the supplier. This difference in order behavior most likely occurred as a result of that the Non food goods segment was operated in a separate company until relatively recently. The different practices still exist in parallel and a common best practice has not been established. This is a matter of aligning the operations at ICA and not an inherent feature of either of the goods segments.

The differences between the two segments provide very different opportunities for implementing slip sheet. It is important to consider that some of the differences are a result of how ICA has set up the operations in separate flows with dissimilar practices. These practices could be aligned across the segments to provide better prerequisites. Some aspects are more difficult or not possible to change, such as the product characteristics.

### 6.1.2 The Immediate Effects and the Financial Potential of Slip Sheet

The result from the potential analysis showed that there is no potential for a wider implementation of slip sheet at ICA. It is the decrease in load factor that eventuates the need for additional containers and further the extra shipping costs, which in turn outweighs the savings in the receiving operations. The research has thereby concluded that by using slip sheet it is not possible to reach a load factor that is satisfactory enough. The findings of unsatisfactory load factors are similar to what Home Decor identified as the main issue in their potential analysis of slip sheet

When doing a sensitivity analysis and changing the ingoing variables, the recommendation to not proceed with the implementation is still valid. The sensitivity analysis included modification of; the cost for shipping, the cost for utilizing the external warehouse Harbor Cargo, and the utilization of the container volumes. The only scenario where there is overall positive savings potential is when the load factor with slip sheet in the container reaches 90%. Utilizing the container volume to 90% with slip sheet is however not possible with today's set up using ISO containers and EUR-pallet dimensions.

An additional factor for reaching a high load factor in the container is the volume utilization of the slip sheet, which depends on how well the distribution boxes and the slip sheet are optimized to each other. Today, the loading of distribution boxes on the slip sheet results in a reduction of the load factor between 2 and 26%. When designing a distribution box, ICA considers several aspects, such as suitability for transportation, in-store displaying, and supplier capabilities. From a transport point of view, there is a lot of work that can be done to optimize the stacking of distribution boxes onto a slip sheet. By optimizing the product characteristics, the packaging efficiency and the loading efficiency can be improved, following the framework from Santén

(2016). Reaching a higher load factor on the slip sheet is not only beneficial in the container flow, but also in the continued flow at ICA after reaching the warehouse.

Investigating at what point slip sheet is attractive is important for the future, in case loose-loading will stop being a possible loading alternative. The trade-off will then be to use either slip sheets or pallets. Pallets are a widespread method used for unitizing goods, meaning that most warehouses have the proper equipment for handling them (White & Hamner, 2005). Further, pallets are the unit load already widely used in ICA's flows today, making that option available with no barriers. The equipment needed for slip sheet generates a need for additional investment, speaking against this loading technique. The relative benefit of slip sheet is that it requires less space in the container (Spencer & Ebeling, 2011). The scenario when slip sheet could be favorable is therefore if that extra space is utilized, as in the case for Big Bolts. Since ICA has a restriction on the height of a pallet based on what fits into their pallet rackings, it is not clear that a slip sheet can be loaded more than a pallet during transportation. The question of whether a slip sheet or a pallet is preferable therefore has to be investigated further at ICA if it is decided to stop loose-loading.

In the survey some of the suppliers indicated that a change to slip sheet would be enclosed by an increase in the rate, leading to additional costs for ICA in the case of implementation. The rate increase was justified by seeing slip sheet as an additional service for ICA. However, in the same way as ICA can make savings from using slip sheet in the receiving operations, the supplier can make savings in the loading operations. The issue initially could be the investment in equipment but in the long run, savings could be realized at both sender and receiver. This creates an opportunity for a lower rate from the supplier instead of a higher one. Additionally, as the salaries increases in Asia where many of ICA's suppliers are located, a more efficient loading method could be of interest. A particular interest could be to make the loading operations more efficient when full containers are shipped directly from the supplier to ICA, as in the case for the Dry goods suppliers and the Non food suppliers shipping FCL.

Although ICA is a large player in Sweden, the situation is not the same if a global perspective is applied. When making changes in a business network, the interdependency to other actors has to be considered (Ford et al., 2008). ICA is highly dependent on the ability to influence other actors in the supply network to make a change in the way of shipping the goods. However, their power to influence others may be limited due to their position in the global market.

### 6.1.3 Additional Effects of an Implementation

As mentioned in the analysis a potential effect of implementing slip sheet is an improved resource allocation due to the reduced variation in the receiving operations. Improved planning can reduce the overall need for staff and other resources. High resource utilization is significantly easier to achieve in a process with lower variation, which can be derived from Kingman's equation (Modig & Åhlström, 2015). To benefit from the reduced variation, ICA must have an organization that is capable to capture the opportunity. If the planning of allocation of resources is not adapted to the operations practice, savings will not be derived. The staffing is currently planned once per week. An investigation regarding how resource planning should be designed, and how often it should be performed to gain the advantage of the reduced variation should be done. The planning must likely be done more often, to realize the benefits of reduced variation and avoid planning of excess resources.

Slip sheet could enable faster turnaround time at the gate of the warehouse, which means the containers could be returned faster. The reduction of handling time also has the potential to reduce the lead time of the delivery, as the goods are unloaded faster into the warehouse. However, it is deemed unlikely that ICA would benefit much from these factors in the short term. Currently, ICA rents the containers per day, and as such an earlier return of the container would not generate any savings. The shortened lead time makes the goods available in the warehouse earlier compared to loose-loading. The difference is only a few hours, and since the lead time is usually several weeks long, it is considered to be a marginal improvement. Both factors could be beneficial in the future if for example the containers are rented per hour, or in other goods flows where the lead times are shorter and the reduction would be more significant.

Another consideration of the warehouse operations is the work environment and the health of the warehouse operators. The Swedish Work Environment authorities have over the years increased the restrictions for manual labor, such as limiting the weight for manual lifting. The permissible working methods are likely to be further restricted, making it a more urgent matter for ICA to move away from loose-loading of containers. If all containers could be unitized, either on pallets or slip sheet, the cost of staff turnover and sick leave could also be decreased. The cost of poor ergonomics is, however, difficult to quantify and must be investigated further.

A potential benefit of transferring the goods to be shipped on slip sheet is a reduction of the goods damaged. The increased stability of the loads prevents collapsed goods and minimizes the need for scrapping items upon arrival. If deciding on changing the way of loading containers, ICA Should have in mind that slip sheet is favorable for receiving intact unit loads at the warehouses compared to both pallets and loose-loading.

Some further considerations regard important future development trends such as salary development and automation. It was concluded that the global salary levels are increasing, and the salary level in the Asia Pacific more than in Europe. The relative increase could make the transition from manual labor more attractive to the Asian supplier base. Automated warehousing solutions are becoming more common, which increases competition in the market. As such, it is reasonable to assume that ICA will increase the level of automation in the warehousing operations over time. Unitizing the goods provides a better interface toward automation than handling loose-loaded goods, as the unit loads can quickly be transferred into the automated system without much additional handling. As such, ICA should consider unitizing the goods to be able to stay competitive in the future.

Sustainability is an increasingly important matter for many companies. ICA has a desire to always strive for reducing the environmental impact of its business. An important factor to consider related to environmental sustainability is transport. As could be seen in the analysis, the demand for transport would increase in a transition to slip sheet. The deterioration of the load factor would cause a significant increase in the number of shipped containers and related emissions. The unitization of the goods would, therefore, work against the company's ambition to reduce the environmental impact of their operations. The increased sustainability in working conditions must be weighed against the increased environmental impact if ICA should unitize the goods.

### 6.1.4 Fulfillment of the Purpose

The purpose of the thesis was to identify the impact of implementing slip sheet in the materials handling in the loose-loaded containerized goods flow at ICA. By evaluating the technology and its impact on the business from multiple perspectives, solid reasoning could be presented. The analysis also gave insight into how changes in the underlying factors may influence the result. The aim was to be able to provide ICA with practical recommendations on how to utilize the technology in their flows. The results indicated that slip sheet would have a significantly negative impact if implemented in the existing setup. As such, the recommendation is to not apply the technology at all. The resulting practical recommendations therefore mainly concern what to consider if slip sheet would be implemented despite not currently being financially attractive, such as if manual handling is further restricted by the Swedish Work Environment authority. The recommendations also provide insight into how the negative impact can be reduced and presents critical factors for a successful implementation. To conclude, the purpose of the thesis was fulfilled, but with slightly different practical recommendations than initially expected.

## 6.2 Contributions and Transferability

In this section, the theoretical and practical contributions of the research will be discussed. The transferability of the results will also be reviewed to give a comprehensive understanding of how the results and recommendations can be used for other actors and industries.

### 6.2.1 Theoretical Contributions

The topic of efficiency in logistics is a relevant matter for almost all companies. This master thesis targets an area of logistics that has only been briefly investigated before. The available academic research on slip sheet is mainly old and as such less applicable to current logistics and warehousing operations. The previous research has predominantly been made regarding the relative benefits of slip sheets compared to pallets, but not compared to loose-loading. Therefore, the research contributed to filling a gap in the existing literature.

The thesis further relates to the theory of unit loads. It is often stated in the existing theory that unit loads should be created whenever possible and that unit loads always are an economically better alternative to loose-loading from a transport perspective. Further, it is stated in the theory that the goods should be handled as few times as possible and that mechanization always should be preferred over manual labor, which mainly considers efficiency and work environment perspectives. This master thesis showed, by applying a holistic perspective, that the creation of unit loads is not always economically viable. The research thereby complements the theory about unit loads and highlights the importance to always consider the context and the characteristics of the flow that is about to be redesigned.

Some actions could have been made to further improve the validity and reliability of the research and recommendations. For example, more time could have been spent on simulating items in the software Cape Pack to attain a higher certainty in the calculated load factors. More suppliers could have been contacted regarding their ability to ship on slip sheet, and a deeper investigation of the potential price increase at the supplier could have brought new insights about the technology attractiveness. Additional and more detailed time studies could have been made of the receiving operations in the warehouses to get a better understanding of the variation in the processes. However, the time frame and available resources in the project set a limit for how extensive the data collection and research could become. All research questions could be addressed, and a thorough analysis of the result could be made based on the theoretical and empirical findings. Since the findings indicated a negative impact in the transition to slip sheet, it is deemed highly unlikely that the recommendation would be changed if more time and resources had been assigned. This was proven by, for example, investigating how changes in several of the underlying factors would affect the outcome, this can be seen in 5.1.2.5. Sensitivity Analysis. For the sake of answering the research questions with a high level of confidence, within the time frame and while using the resources available, the method applied was considered appropriate.

### 6.2.2 Practical Contributions

The research project was initiated by ICA since the existing knowledge on the topic of slip sheet was scarce. The existing published research is very limited and provided little guidance regarding when slip sheet is beneficial or not. The research project aimed to provide ICA with a recommendation on how to utilize slip sheet in their logistics operations. The resulting recommendation of the project is to not utilize slip sheet at all, complemented with suggestions on how to handle drastic changes in the preconditions. As such, ICA can utilize the model for calculating the potential of slip sheet as a tool to monitor the attractiveness of the technology. The extensive analysis of the theoretical and empirical findings further provides ICA with recommendations for other areas to investigate to improve the efficiency in their existing operations.

### 6.2.3 Transferability

The applicability of the recommendations for other actors and other settings is an important aspect of the research. This project was carried out by performing several case studies both at ICA and other actors in different types of industries. It must be considered that the sample size of case studies is relatively small and that the industries. although different in many aspects, also have several similarities. The contextual factors, such as product characteristics and supplier relationships are essential to include in the analysis, and as such the transferability of the recommendations becomes context-dependent. A similar method for analysis, like the model presented in Potential for conversion to slip sheet could be used to evaluate the same case for actors in different settings. For companies in a context similar to ICA's, the key findings and recommendations can be assumed to hold true.

## 6.3 Areas for Future Investigation and Research

The scope of the analysis was loose-loaded containers sent by sea freight. Since container freight has long lead times it is considered important to utilize the capacity well. The potential of slip sheet resides in the possibility to reduce the amount of loose-loaded goods while maintaining a higher load factor in the container compared to pallets. The practice of loose-loading is only prevalent in the container flows at ICA. Goods arriving by other modes of transportation, such as semi-trailers, are all loaded on pallets. As it turned out in the analysis, the high load factor was impossible to maintain in a transfer to slip sheet. As such, the negative financial impact outweighed the positive effects of reduced materials handling costs. However, from the case of Big Bolts, it could be seen that a conversion from pallets to slip sheet could generate a good result. There is also previous research indicating that there is a potential in such a transition, presented in several cases by Spencer and Ebeling (2011). As such, the authors suggest that an investigation is made regarding the potential of converting the palletized flows at ICA to slip sheet.

A framework could be created to support the purchasers at ICA in selecting the best-suited loading practice for each supplier. The framework could be extended to include both palletized containers and semi-trailers, as well as additional segments of goods that may be of interest. The aim of the framework should be to determine the distinct volumes for which each unit load is the most appropriate, considering both the savings and costs incurred in each case. The framework could also take into consideration which node should receive the goods in the warehouse structure.

Another suggestion for future research is to make a deeper investigation regarding the possibilities to apply automation in the goods receiving operations. The degree of automation is steadily increasing in warehousing, but the goods receiving operations are still relatively unchanged. Important aspects to analyze are if there are any barriers to implement automated solutions and to understand how these barriers can be addressed.

A final important reflection is whether it is accurate to compare a relatively poor functioning loose-loaded flow with a well-functioning slip sheet flow. It is possible that by improving the information exchange with the supplier or implementing tools to assist the operators, similar reductions in variation could be achieved also for loose-loaded containers. The philosophy of 5S, Kaizen, or Lean logistics could also be applied to improve the efficiency of the existing processes. As such, there may be room for improvement for ICA to reduce the variation already now in the existing setup and reap many of the associated benefits. The possibilities to improve the current practices without changing the loading practice should be further investigated to identify ways to make the operations better, both in terms of operational efficiency and working environment.

# 7 Conclusions

The purpose of this master thesis was to identify the potential of using slip sheet in the materials handling in the loose-loaded containerized goods flow for Non food and Dry goods at ICA. The three research questions that were formulated to fulfill the purpose and aim of the thesis are answered below.

1. *What is the current flow of loose-loaded containerized goods to Sweden in terms of volumes, suppliers, type of goods, and receiving warehouses?*

Each year, ICA receives about 2000 TEUs of Dry goods and 1600 TEUs of Non food goods to the warehouses in Sweden. The mapping shows that the two examined segments of goods have significant differences both in terms of supplier base, inherent product characteristics, and in how they are operated. The Non food segment has a wide supplier base with frequent changes, whereas the Dry goods segment has a small and relatively stable supplier base. The Non food goods are often bulky and large, whereas the Dry goods are uniform and manageable. The Non food goods are always ordered according to demand and are either shipped directly to ICA or sent via a consolidation terminal in Asia. The Dry goods are always ordered in full container loads from the supplier and shipped by sea freight to the port of Gothenburg. The containers with Dry goods are then unloaded in the external warehouse Harbor Cargo.

2. *What are the immediate effects and the financial potential of implementing slip sheet at ICA's central warehouses, Warehouse 1 and Warehouse 2, and/or extending the use of slip sheet at Harbor Cargo in Gothenburg?*

The significant differences between the two goods segments create very different preconditions for implementing slip sheet. By evaluating the technology from multiple perspectives, it was found that there is no potential for conversion in either of the flows. For the Non food segment, the bulky items and small order volumes make it difficult to transfer the goods to slip sheet. For the Dry goods segment, the main issue is related to the loss in load factor that surfaces in the transition from loose-loaded to slip sheet. An inevitable loss of at least 15% is related to the poor interface between EUR-pallets and ISO containers. An additional loss surfaces in the interface between the distribution box and the EUR-pallet, where it is clear that some distribution boxes are poorly adapted to fit the pallet dimensions. The recommendation is, therefore, to not implement slip sheet, unless there is a drastic change in some of the underlying factors such as the shipping rates or if the products are redesigned to achieve a higher load factor. The supplier base analysis showed that a majority of the suppliers in both goods segments already have the technology in place, which would facilitate an eventual transition.

3. *What are the additional effects of implementing slip sheet?*

In addition to the immediate effects and the financial potential of slip sheet, some potential effects were studied. The strenuous work of emptying loose-loaded containers can become subject to additional restrictions from the Swedish Work Environment authorities. In such a case, some type of unit load must be implemented and slip sheet may pose a relative advantage to regular pallets. A transfer to unit loads would likely improve the working conditions and reduce employee turnover and sick leave.

Another benefit of using slip sheet is the reduced time and variation in the unloading that enables better resource planning. The ability to plan the resources more accurately may increase the efficiency of the warehouse over time. The same reasoning follows for the suppliers in Asia, which may reap the same benefits of reduced handling time. The attractiveness for the suppliers in Asia may increase over time as the relative salary development is larger there than in Europe.

The goods in the containers are better secured when the goods are loaded on slip sheet. As such, there is an opportunity that the amount of damaged and collapsed goods can be reduced if the technology is used. The unitized goods are also better adapted to potential future automation of the receiving processes.

A change in the way of loading containers is highly dependent on the relationships with other actors in ICA's supply network. ICA is a relatively small player in the global market, limiting their negotiation power. Since a transition to slip sheet world require close collaboration with the suppliers and much effort from all parties involved, it can be difficult for ICA to make a successful implementation.

A clear downside of a transition to slip sheet is that the total amount of traffic is increased to compensate for the decrease in load factor. This leads to increased emissions and a greater environmental impact, which is not well aligned with ICA's overall aim to reduce their environmental impact and become more sustainable.

Slip sheet may not be the right solution for the current operations at ICA. However, the alternative to keep the existing practice of loose-loading, but adapting it to reap some of the benefits, remains. This relates to for example improving the knowledge about the incoming shipments to reduce variation and enhance resource allocation. It is also possible to adapt the distribution box sizes to attain a higher load factor on pallets, creating better utilization of the space in the warehouses. As competition increases in the market, it becomes increasingly important to have an efficient and modern logistics solution. ICA must continuously strive to improve the logistics to maintain the position as a market leader.

# 8 References


Access Logistics. (n.d.). Loading metre and Pallets Definitions. Retrieved 2020 March 23 from https://accesslogistics.eu/useful-information/

Ackerman, K.B. (1990). *Unit Loads*. *Practical Handbook of Warehousing*. (3. ed.). Boston, MA: Springer.

Arbetsmiljöverket. (2012). *Bedöm Risker vid Manuell Hantering - Lyfta/Bära* [Pamphlet]. Retrieved from https://www.av.se/globalassets/filer/publikationer/broschyrer/bedom-risker-vid-manuell-hantering-lyfta-bara-broschyr-adi627.pdf

Arbetsmiljöverket. (2020). Manuell hantering. Retrieved 2020 April 22 from https://www.av.se/halsa-och-sakerhet/arbetsstallning-och-belastning---ergonomi/manuell-hantering/

Baudin, M. (2005). *Lean logistics: the nuts and bolts of delivering materials and goods*. New York, NY: Productivity Press.

Bell, E., Bryman, A., & Harley, B. (2018). *Business research methods* (5. ed.). Oxford: Oxford university press.

van den Berg, J. P. & Zijm, W. H. M. (1999). Models for warehouse management: Classification and examples, *International Journal of Production Economics*, *59*(1–3), 519-528. doi: https://doi.org/10.1016/S0925-5273(98)00114-5

Björklund, M., & Paulsson, U. (2014). *Academic papers and theses: to write and present and to act as an opponent*. Lund, Studentlitteratur.

Bortfeldt, A., & Wäscher, G. (2013). Constraints in container loading – A state-of-the-art review. *European Journal of Operational Research*, *229*(1), 1-20. doi: https://doi.org/10.1016/j.ejor.2012.12.006

Bouma, J. C. (1980). Potential for Slip-Sheet Shipment of Groceries in Trailers. *Journal of Food Distribution Research*, *11*(1), 61-64. doi: 10.22004/ag.econ.27101

Bouma, J. C., & Shaffer, P. F. (1982). *Evaluation of Slipsheets for Unitized Shipment of Groceries in Trailers*. Washington, D.C.: U.S. Department of Agriculture.

Brinkmann, S., & Kvale, S. (2015). *Interviews: Learning the craft of qualitative research interviewing* (3. ed.). Thousand Oaks, CA: Sage Publications.

B&B Attachments. (2017, March 12) Slip sheet Attachment for Forklifts. *Material Handling & Logistics*. Retrieved from https://www.mhlnews.com/new-products/article/22053283/slip-sheet-attachment-for-forklifts-new-products

Castetter, T. (2019). Slip sheets: Giving Pallets the Slip [Blog post]. Retrieved from https://www.toyotaforklift.com/blog/slip-sheets-giving-pallets-the-slip

Conger. (n.d.). Cascade-Push-Pulls [photography]. Available from https://www.conger.com/product/cascade-push-pull/

Corpal. (n.d.). Slip Sheet [photography]. Available from https://corpal.fr/en/solutions-2/carry-solutions/slip-sheet/

Creswell, J. W. (2014). *A concise introduction to mixed methods research*. Thousand Oaks, CA: Sage Publications.

Cudahy, B. J. (2006). *Box Boats: How container ships changed the world.* New York: Fordham University Press.

Daboub, J. J., Trevino, J., Liao, H. H., & Wang, J. (1989). Computer aided design of unit loads. *Computers & industrial engineering*, *17*(1-4), 274-280. doi: https://doi.org/10.1016/0360-8352(89)90074-0

Denscombe, M. (2014). *The good research guide: for small-scale social research projects* (5. ed.). Berkshire: McGraw-Hill Education.

Eltete. (n.d.). History of slip sheets. Retrieved 2020 February 4 from https://slipsheet-eltete.co.uk/slip-sheets/history-of-slip-sheets/

Flick, U., von Kardorff, E., & Steinke, I. (2004). *A companion to qualitative research*. Thousand Oaks, CA: Sage Publications.

Ford, D., Gadde, L. E., Håkansson, H., Snehota, I., & Waluszewski, A. (2008). Analysing business interaction. *IMP Journal*, *7*(1), 82-103. Retrieved from https://www.impgroup.org/uploads/papers/6211.pdf

Fowler Jr, F. J. (2014). *Survey research methods* (5. ed.). Thousand Oaks, CA: Sage Publications.

Goldsby, T. J., & Martichenko, R. (2005). *Lean six sigma logistics: Strategic development to operational success*. Boca Raton, FL: J. Ross Publishing.

Griffee, D. T. (2005). Research Tips: Interview Data Collection. *Journal of Developmental Education, 28*(3), 36-37. Retrieved from https://files.eric.ed.gov/fulltext/EJ718580.pdf

Griptech. (n.d.). Kooi-rollerforks [photography]. Available from https://www.griptech.eu/en/products/attachments/rollerforks.html

Gu, J., Goetschalckx, M., & McGinnis, L. F. (2007). Research on warehouse operation: A comprehensive review. *European Journal of Operational Research, 177*(1), 1-21. doi: https://doi.org/10.1016/j.ejor.2006.02.025

Human Resources Online. (2019). Expected salary increases in Asia Pacific for 2020. Retrieved 2020 April 29 from https://www.humanresourcesonline.net/expected-salary-increases-in-asia-pacific-for-2020

ICA Gruppen. (n.d.). ICA Sverige - Sveriges ledande dagligvaruaktör. Retrieved 2020 January 29 from https://www.icagruppen.se/om-ica-gruppen/var-verksamhet/ica-sverige/

IFCO Systems. (2017). Best Practices for Pallets and Containers in Automated Systems. Retrieved 2020 March 19 from https://www.ifco.com/best-practices-for-pallets-and-containers-in-automated-systems/

iGPS. (2018, August 23). What are ISO standard pallet dimensions? [Blog post]. Retrieved from https://igps.net/blog/2018/08/23/what-are-iso-standard-pallet-dimensions/

Jamrus, T., & Chien, C. F. (2016). Extended priority-based hybrid genetic algorithm for the less-than-container loading problem. *Computers & Industrial Engineering, 96*, 227-236. doi: https://doi.org/10.1016/j.cie.2016.03.030

Johnson, G. R. (1980). The Pros And Cons Of slip sheets. *Journal of Food Distribution Research*, *11*(1), 64-69. doi: 10.22004/ag.econ.27073

Kay, M. G. (2012). *Material handling equipment.* North Carolina State University: Fitts Dept. of Industrial and Systems Engineering.

Kronus. (n.d.). Europallar (EPAL) [photography]. Available from https://www.kronus.eu/se/produkter/pallar/epal

Lamboni, M. (2018). Global sensitivity analysis: a generalized, unbiased and optimal estimator of total-effect variance. *Statistical Papers*, *59*(1), 361–386. doi: https://doi-org.proxy.lib.chalmers.se/10.1007/s00362-016-0768-5

Laundrie, J. F. (1986). *Unitizing goods on pallets and slipsheets.* Madison, WI: Department of Agriculture, Forest Service, Forest Products Laboratory.

Leblanc, R. (2019, August 8). How Pallet Collars Will Fit Into 2019 Industrial Packaging Trends [Blog post]. Retrieved from
https://packagingrevolution.net/how-pallet-collars-will-fit-into-2019-industrial-packaging-trends/

Lumsden, K. (2007). *Fundamentals of Logistics*. Gothenburg: Logistics and Transportation Division at the Department of Technology Management and Economics at Chalmers University of Technology.

McCrea, B. (2019). Six warehouse management trends to watch in 2019. *Modern Materials Handling, 74*(4), 58-61. Retrieved from
http://web.a.ebscohost.com.proxy.lib.chalmers.se/ehost/pdfviewer/pdfviewer?vid=4&sid=4db3b6bc-0080-4159-bb69-6c4de5f195b4%40sdc-v-sessmgr01

McDonald, C. M. (2016). Integrating packaging and supply chain decisions: Selection of economic handling unit quantities. *International Journal of Production Economics*, *180*, 208-221. doi: https://doi.org/10.1016/j.ijpe.2016.08.003

Meijer Handling Solutions. (n.d.-a). Rollerforks. Retrieved 2020 February 6 from
https://meijer-handling-solutions.com/products/kooi-palletless/rollerforks/

Meijer Handling Solutions. (n.d.-b). Rollerforks Push-Pull Manual Forkpositioner. Retrieved 2020 February 6 from
https://meijer-handling-solutions.com/products/kooi-palletless/rollerforks-push-pull/

MÍkva, M., Prajová, V., Yakimovich, B., Korshunov, A., & Tyurin, I. (2016). Standardization: one of the tools of continuous improvement. *Procedia Engineering, 149*, 329-332. doi: https://doi.org/10.1016/j.proeng.2016.06.674

Modig, N., & Åhlström, P. (2015). *Detta är lean : lösningen på effektivitetsparadoxen* (2. ed.). Stockholm: Rheologica.

Mulcahy, D. (1999). *Materials handling handbook*. New York: McGraw-Hill Professional.

Murman, E., McManus,H., Weigel, A., & Madsen, B. (2012). Introduction to Lean Six Sigma Methods. January IAP 2012. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.

PAKi Logistics. (n.d.). Euro pallet. Retrieved 2020 February 20 from
https://www.paki-logistics.com/en/standard-pallets-and-boxes/euro-pallet

Pålsson, H., Finnsgård, C., & Wänström, C. (2013). Selection of packaging systems in supply chains from a sustainability perspective–the case of Volvo. *Packaging Technology & Science, 26*(5), 289-310. doi: https://doi.org/10.1002/pts.1979

Remer, D. S., & Nieto, A. P. (1995a). A compendium and comparison of 25 project evaluation techniques. Part 1: Net present value and rate of return methods, *International Journal of Production Economics*, *42*(1), 79-96. doi:
https://doi.org/10.1016/0925-5273(95)00104-2

Remer, D. S. & Nieto, A. P. (1995b). A compendium and comparison of 25 project evaluation techniques. Part 2: Ratio, payback, and accounting methods. *International Journal of Production Economics*, *42*(2), 101-129,
doi: https://doi.org/10.1016/0925-5273(95)00105-0

Rodrigue, J-P. (2020). *The Geography of Transport Systems* (5. ed.). New York: Routledge.

Santén, V. (2016). *Towards environmentally sustainable freight transport: shippers' logistics actions to improve load factor performance.* (Doctoral thesis, Chalmers University of Technology, Gothenburg, 4165). Retrieved from
http://publications.lib.chalmers.se/records/fulltext/243257/243257.pdf

Saunders, M., Lewis, P., & Thornhill, A. (2015). *Research Methods for Business Students* (7. ed.). New York, NY: Pearson Education Limited.

Sheposh, R. (2019). Sensitivity analysis. *Salem Press Encyclopedia of Science*. Retrieved from
http://eds.b.ebscohost.com/eds/detail/detail?vid=8&sid=d3c53e38-29dd-449f-a5ff-12c3ad259f1b@pdc-v-sessmgr01&bdata=JkF1dGhUeXBlPXNzbyZzaXRlPWVkcy1saXZlJnNjb3BlPXNpdGU=#AN=119214373&db=ers

Sopack. (n.d.-a). Slip Sheets are manipulated by a Push-Pull attachment [photography]. Available from https://slipsheet.info/palletless-handling/

Sopack. (n.d.-b). Push Pull attachment. Retrieved 2020 February 6 from
https://slipsheet.info/push-pull-attachment/

Spencer, D. K., & Ebeling, C. W. (2011). *Push/Pull & Slipsheet Handling Manual*. Cascade Corporation. Retrieved from
https://www.cascorp.com/web2/downloads.nsf/links/6027894/%24FILE/PHManual.pdf

Supply Chain Asia. (2018, May 9). The pallet standards minefield [Blog post]. Retrieved from
http://supplychainasia.org/pallet-standards-minefield/

TFH Hire Services. (n.d.). Shipping Container 20' [photography]. Available from https://tfh.com.au/product/shipping-container-20/

Tompkins, J. A. (1994). *The Distribution Management Handbook.* New York, NY: McGraw-Hill.

Twede, D., Mollenkopf, D., & Guzman-Siller, C. (2007). A Market-Driven Investigation of Pallet Trends in Grocery Chains. *Journal of Food Distribution Research*, *38*(1), 161-169. doi: 10.22004/ag.econ.162280

White, M. S., & Hamner, P. (2005). Pallets move the world: the case for developing system-based designs for unit loads. *Forest Products Journal*, *55*(3), 8-16. Retrieved from http://web.a.ebscohost.com.proxy.lib.chalmers.se/ehost/pdfviewer/pdfviewer?vid=2&sid=834c9c57-d837-4dff-8b2d-0334c79716d6%40sessionmgr4007

Wolters, W. T. M., & Mareschal, B. (1995). Novel types of sensitivity analysis for additive MCDM methods. *European Journal of Operational Research, 81*(2), 281-290. doi: https://doi.org/10.1016/0377-2217(93)E0343-V

Wruck, S., Vis I. F. A., & Boter, J. (2017). Risk control for staff planning in e-commerce warehouses. *International Journal of Production Research*, *55*(21), 6453-6469. doi: 10.1080/00207543.2016.1207816

Yard, S. (2000). Developments of The Payback Method, *International Journal of Production Economics*, *67*(2), 155-167.
doi: https://doi.org/10.1016/S0925-5273(00)00003-7

# Appendix I

Survey questions to the suppliers:

1. Do you have the ability to ship goods on slip sheet?
2. Are you able to provide Sheets with the dimension 1200 * 800 mm?
3. What is the approximate load factor when shipping on slip sheet 1200 * 800 mm (in percent or cbm)?
4. What is the approximate load factor when shipping loose loaded goods (in percent or cbm)?
5. Is there a difference in the shipping cost for slip sheet vs loose loaded?
   - If yes, how much?

DEPARTMENT OF TECHNOLOGY MANAGEMEN AND ECONOMIC
DIVISION OF SUPPLY AND OPERATIONS MANAGEMENT
CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden
www.chalmers.se