Master's Thesis

Improving Inbound Logistics through Supplier Relationships and Handling of Goods

A case study at Boozt Fashion AB

The Faculty of Engineering at Lund University
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Sweden, Lund, May 2024

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Preface

We are writing this knowing that it might be the last assignment we must complete for our studies at Lund University. Writing the master thesis has not been easy. The past semester has been devoted to our research, which has taught us a lot about e-commerce and inbound logistics operations. We sincerely hope that our research can help expand the body of knowledge for future studies.

The knowledge we acquired while studying at Lund University will continue to be useful to us in the future, and we will value our time there. Being able to choose to attend a university like Lund University makes us feel fortunate and joyful.

We would like to express our gratitude to Jan Olhager for guiding us throughout this project and giving us valuable insights and advice. Moreover, we would like to thank Lisette, Ronni, and Stina from Boozt, whose expertise and collaboration have been instrumental in completing this work.

Additionally, we would like to extend our appreciation to our study friends whose support has enriched our research experience. A special thanks to Arsen, Duarte, Soren, Rohan, and Kratos for their assistance and unwavering support during challenging times.

Finally, we would like to thank our family for their unconditional love and encouragement; without them, this project would not have been possible. A special thanks to Alma, whose support has been unquestionable throughout the process and has been a constant source of motivation to finish the thesis.

Tim Eijkhout & Elias Janineh
Lund, May 2024

Abstract

Title: Improving the Inbound Logistics through Supplier Relationships and Handling of Goods - A Case Study at Boozt Fashion AB

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Background: E-commerce companies have grown considerably, leading to a changing role in logistics and supply chain management. Events such as the COVID-19 pandemic have significantly boosted the global e-commerce market, leading to traditional businesses adopting an online sales model. Therefore, optimising e-commerce operations has become a focus of study in recent years, where e-commerce has improved operational efficiency and customer satisfaction. Among these operations, the inbound process is a critical step that determines the success of an e-commerce company. The success of e-commerce was led by factors such as rising customer demand for short delivery windows, which resulted in increased transportation trucks, more frequent dispatch, and the inability to use full capacity trucks. For that reason, a company that applies e-commerce should structure its operations in a reactive and efficient way that requires different solutions for order fulfilment and operation management, making inbound logistics and e-commerce an interesting research area.

Purpose: The purpose of this thesis is to develop recommendations for warehouse operations and supply relationships in order to improve inbound logistics performance.

Research questions:
RQ1: How could goods be received from suppliers and managed at the receiving warehouse depending on item characteristics?
RQ2: What does the current situation of Boozt's inbound look like?
RQ3: How do the suppliers perform compared to each other for Boozt?
RQ4: What should the relationship look like between Boozt and their Suppliers?

Methodology: A single case study and borrowed aspects from design science research with a deductive research approach, conducted by utilising both qualitative and quantitative data from semi-structured interviews, observations and literature.

Findings: To summarise the findings of this thesis, the main issues identified are related to the handling of incoming goods and the performance of suppliers. When the goods are handled, they are not automatically allocated to a certain location but are manually allocated based on experience. Also, through a VSM and Swimlane diagram, it was shown the VAS/Sorting processes of the goods take a significant amount of time due to the suppliers delivering the goods in mixed SKUs. The findings reveal several possible solutions which were suggested in the analysis. Firstly, the random goods allocation should be replaced by a two-criteria class-based policy such as the ABC-FSN matrix. Secondly, an MCDM analysis of the vendors was done, and the results showed that some vendors were underperforming. Following this, recommendations were made to the company for ways to strengthen their suppliers' performance. Lastly, the relationships between the company and the vendors should be treated in a way that is based on the supplier evaluation and the type of relationship identified.

Keywords: Inbound Logistics, Warehouse operations, Supplier Evaluation, Multi-Criteria Decision-making, AHP-TOPSIS, Mapping, E-commerce, Supplier Relationship

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Abbreviations

3PL	Third-Party Logistics
AHP	Analytic Hierarchy Process
AS/RS	Automated Storage and Retrieval System
AS1/AS2/AS3	Autostore 1/2/3
BI	Business Intelligence
CPO	Chief Product Officer
CTO	Chief Technology Officer
DSR	Design Science Research
EAN	European Article Number
ERP	Enterprise Resource Planning
KPI	Key Performance Indicator
MCDM	Multi-Criteria Decision-Making
SCM	Supply Chain Management
SKU	Stock Keeping Unit
SRM	Supplier Relationship Management
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
VAS	Value Added Services
VSM	Value-Stream Mapping
WMS	Warehouse Management System
C/T	Cycle Time

1. Introduction

The introduction chapter provides an overview of the e-commerce topic, highlighting the company itself and its logistical problems. Then, the research questions were formulated aimed at addressing the problems, and the purpose of the thesis was presented. The main purpose is to solve the problems and make recommendations for the company. Thereafter, the focus of the research and the delimitations are described.

1.1 Background

In the last decades, e-commerce companies have grown considerably, leading to a changing role in logistics and supply chain management. Events such as the COVID-19 pandemic have significantly boosted the growth of the global e-commerce market, with an annual increase of around 13.5% (Zennaro et al., 2022). Boosted by a growing digital economy, e-commerce forced traditional businesses to adopt an online sales diversification model (International Trade Administration, 2021). These events have caused a cascade effect extended through several sectors, such as buyers, distributors, and suppliers in the supply chain (Butt, 2021). Alicke, Barriball, & Trautwein (2021) stated that these developments have led to certain trends within logistics, such as digital supply chains, supply chain investments, and relocation. Nowadays, supply chain organisations will transform their networks into connected, intelligent, scalable, and customisable ecosystems. This transformation leads to more supply chain investments in people and systems, emphasising how supply chains and the benefits of investments are valued. Moreover, relocation continues to increase as a trend where more resilient companies capture more growth than less resilient rivals, providing a clear performance advantage (Alicke, Barriball, & Trautwein, 2021).

Therefore, Hu & Deng (2023) stated that optimising e-commerce operations has become a focus of study in recent years, where e-commerce has improved operational efficiency and customer satisfaction. Among these e-commerce operations, the inbound process is a critical step that determines the success of an e-commerce company. The inbound operation involves processes such as receipt, handling, and storing goods, which can be optimised to reduce costs, increase efficiency, and improve customer satisfaction. According to Zennaro et al. (2022), when focusing on features typical for e-commerce, orders are small order scales, large item count, unexpected seasonality order patterns, and high service level expectations. However, Muñoz-Villamizar et al. (2021) state that companies have been competing for faster shipping to customers due to rising consumer demand for short delivery windows. The competition translates into not using the full capacity of trucks, requiring more frequent dispatch, which leads to increased transportation costs. Therefore, a company that wants to apply e-commerce should structure the operations in a reactive and efficient way, which requires different solutions such as terms of order fulfilment, operations management and information technology systems (Zennaro et al., 2022). This has created a gap in understanding the functionality of e-commerce and its inbound logistics, which, therefore, has to be researched.

1.2 Company Description

The multi-brand online fashion & lifestyle shop Boozt was founded in 2007; however, it was only an outsourcing company for fashion back then. Bordering on bankruptcy, Boozt decided to rethink its strategy in 2011 and transform it into what it is today, with a slight shift in 2015 from fast fashion to a more premium brand. In 2011, Boozt started with a new management team and relaunched it, making it a multi-brand webstore. This new approach also came with implementing their own technology platform, which allows them full control over their supply chain, customer experience and the actual technology (Boozt, 2024a). In 2017, they built their current warehouse in Ängelholm using an automated storage and retrieval system developed by Autostore. With that, their own ERP system, FastLane, was created. Shortly after, in 2019, Boozt developed FastBrain, their custom WMS integrated with the Autostore system (Sjölin, 2020). Boozt's Logistic Project Manager, as well as their Production Manager, mentions that Boozt has developed their own booking tool for suppliers, which allows the suppliers to book a time slot for when to arrive at the inbound location of Boozt's warehouse. Currently, the suppliers with the booked time slot are being prioritised first to ensure that their goods are being handled (Logistic Project Manager and Production Manager Inbound at Boozt, 2024).

Boozt's Logistic Project Manager, as well as their Production Manager, also says that today, Boozt is a company with more than 1000 brands split into the main categories: Men, Women, Kids, Sports, Beauty, and Home. Currently, Boozt has its headquarters in Malmö and two physical stores, one in Malmö and one in Copenhagen. Their main warehouse is also in Ängelholm, the world's largest Autostore warehouse. The warehouse consists of the Autostore, which is split up into three Autostore cubes called Autostore 1, 2, and 3. Together, these three consist of 1150 robots and 1.2 million bins. For the goods that do not go into the Autostore directly, classical racks are available for the pallets and hangers for the special items. Lastly, bulky items, such as mirrors, chairs, etc., are being shipped and handled in a separate warehouse in Helsingborg (Logistic Project Manager and Production Manager Inbound at Boozt, 2024).

The company's vision is to become the leading Nordic department store with values based on trust, freedom, and responsibility (Boozt, 2024c). Moreover, Boozt does not want to be seen as a fast fashion company; instead, their strategy focuses on offering premium brands and higher quality products (Boozt, 2024c). Today, the technology platform mentioned previously is referred to as "the solar system," this technology is central to all the company's data and organisational activities, as shown in Figure 1.1 (Boozt, 2024e).

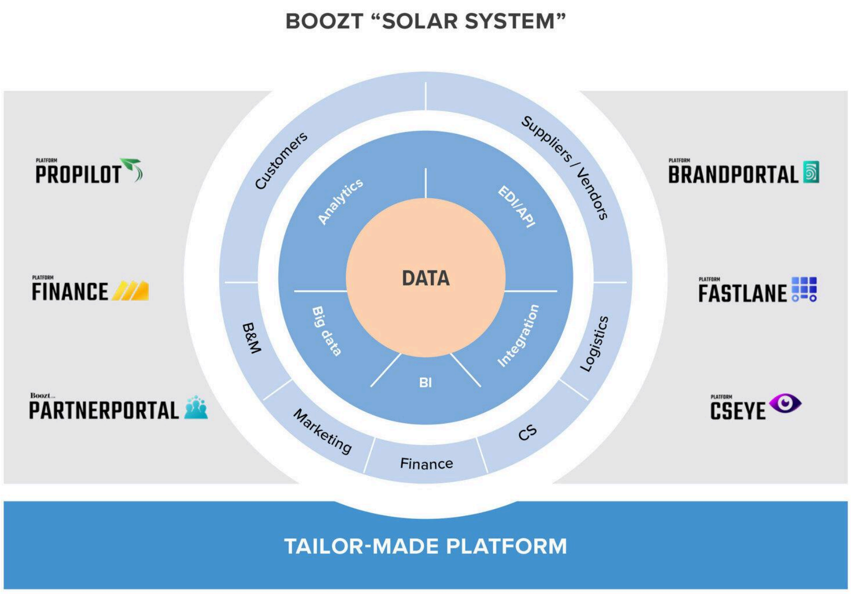

Figure 1.1: Boozt's own created "Solar System" (Boozt, 2024e).

1.3 Problem Description

According to Boozt's Chief Technology Officer (CTO), Boozt is experiencing certain problems in its inbound logistics. These logistics are crucial for the company because they are the starting point of the incoming goods being processed, stored, and sent away. Therefore, each mistake or problem that occurs will have a significant impact on the outbound efficiency. Multiple areas of the inbound processes can cause problems, mainly related to delivery, data quality, and handling (CTO at Boozt, 2024).

In particular, Boozt's Logistic Project Manager and its Production Manager highlight that the delivery times of the goods from suppliers have been causing problems for Boozt. Therefore, they have created a Booking Window Tool where the brands book a time slot for when they should deliver. However, not all brands follow this. Discussions with distributors are taking place to get them to book time slots. A current issue with the booking tool is that not all the suppliers have signed the new contract that mentions the utilisation of the booking tool. At the same time, Boozt does not currently know which supplier has signed the contract. As a result, some suppliers arrive outside their assigned time slot without Boozt knowing if that specific supplier has signed the contract, leading to worse results and control over their receiving operations (Logistic Project Manager and Production Manager Inbound at Boozt, 2024).

Moreover, the CTO states that each brand's deliveries can vary. These incoming deliveries are pallets, which are very mixed regarding items. According to Boozt, every item should be optimally sorted based on the Stock Keeping Unit (SKU). Each sorting that the brand does not do has to be done by Boozt, which leads to more costs, resources, and time. Additionally, the data quality from the brands is mixed, and Boozt relies on good data to get the items on location as fast as possible. Boozt must contact brands for missing information if data is missing, which takes time. Lastly, handling the incoming items creates a problem for Boozt's inbound logistics. Boozt wants to add additional data to the items, such as weight, length, width, height, and picture, which should be done efficiently and cost-effectively for the operators. With this data and the items in a proper state, Boozt wants to place the items in the right place on the first try, where the system should tell the operator which zones the items should be put in to minimise touches and get the first placement of goods correct (CTO at Boozt, 2024).

1.4 Purpose of Thesis

The purpose of this thesis is to develop recommendations for warehouse operations and supply relationships in order to improve inbound logistics performance.

Therefore, this research contributes to more knowledge about inbound logistics and problems within e-commerce. This way, this research helps the company address its problems and minimise its costs. In order to possibly solve the problems Boozt is facing, a certain set of main- and sub-questions will be answered, which are as follows:

RQ1: How could goods be received from suppliers and managed at the receiving warehouse depending on item characteristics?

RQ2: What does the current situation of Boozt's inbound look like?

RQ3: How do the suppliers perform compared to each other for Boozt?

RQ4: What should the relationship look like between Boozt and their Suppliers?

1.5 Focus and Delimitations

The research will focus on Boozt's incoming goods until they are stored in the Ängelholm warehouse. The problem description, given previously, described the delivery, handling, and data of incoming goods. Therefore, the main focus will be on these parts, and this will limit the scope from the moment the goods come in until they are stored in the warehouse. The scope will be limited to only looking at the goods and operations involving the main Ängelholm warehouse and not the one specialised for bulky items located in Helsingborg. Lastly, only Boozt’s main suppliers will be looked at, therefore, not all of them will be included. Therefore, the scope of the research will be focussed on the suppliers, receiving, handling and put-away of the Ängelholm warehouse as shown in Figure 1.2.

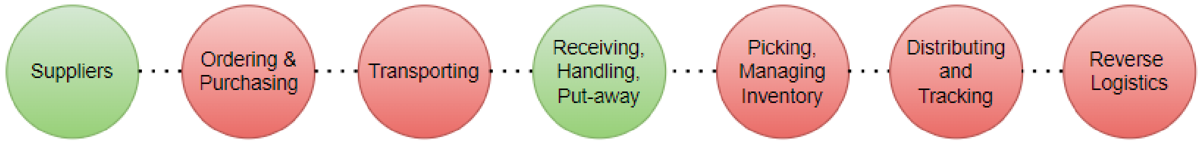

Figure 1.2: The scope of the research

1.6 Thesis Outline

Chapter 1: Introduction

The introduction chapter provides an overview of the e-commerce topic, highlighting the company's logistical problems. Then, the research questions were formulated to address the problems, and the purpose of the thesis was presented. The main purpose is to solve problems and make recommendations for the company. Thereafter, the focus of the research and the delimitations are described.

Chapter 2: Methodology and Method

The research requires an approach, which is described in Chapter 2. This chapter includes how the research will be approached and what strategies will be used. These strategies include research strategies and how the data will be collected. Thereafter, the credibility of the study will be discussed.

Chapter 3: Theoretical Framework

This chapter includes literature research, which provides a deeper understanding of inbound logistics and the literature required to solve the problem. The chapter describes the supply chain management of inbound logistics and how these can be mapped. Thereafter, supplier relationship management is highlighted, together with certain tools and frameworks used to evaluate this. Lastly, warehouse operations are researched, and the processes, policies, and equipment are outlined.

Chapter 4: Empirical Study

The empirical study includes all the company data that has been gathered and measured. This chapter includes the company description and the functionalities of the departments that communicate together. Thereafter, the warehouse design and operations are described which include each operation within the warehouse regarding receiving, put-away, picking and shipping. Moreover, the times of different processes within these operations have been manually measured. Lastly, the information regarding supplier relationships is gathered through interviews and observations.

Chapter 5: Analysis and Results

This chapter highlights the analysis and the data results regarding observations, measurements and literature. At first, the warehouse is discussed, and its operations regarding refill are based on the mapping that has been done. Afterwards, the characteristics of the maps are analysed and discussed whether there is opportunity for improvement or change in the processes of the inbound logistics. Then, the suppliers are evaluated, analysed and discussed using the hybrid AHP-TOPSIS approach. Lastly, the results of the AHP-TOPSIS approach are used to identify what kind of relationships Boozt has with its suppliers and how these relationships should be approached and improved based on the results.

Chapter 6: Conclusion and Recommendations

Finally, the conclusion is made, including answering the research questions proposed in Chapter 1. Moreover, based on the analysis and results, recommendations are being made for Boozt to improve its inbound logistics and supplier relationships. Afterwards, the limitations and future research regarding this topic are provided.

2. Methodology and Method

The research requires an approach, which is described in Chapter 2. This chapter includes how the research will be approached and what strategies will be used. These strategies include research strategies and how the data will be collected. Thereafter, the credibility of the study will be discussed.

Methodology and method within a research depicts in what way and which method will be required to conduct the research. According to Saunders, Thornhill, and Lewis (2019), research philosophy is a system of beliefs and assumptions about developing knowledge. It is developing new knowledge in a particular field, which requires a process of exploring and understanding its own research philosophy. The research onion model is used to explore and understand a research topic. Melnikovas (2018) states that the research onion creates a steady basis for justifiable research, where this model can be designed step-by-step and utilised as a main academic research model. Moreover, Mardiana (2020) expands on Melnikovas (2018) by stating that the research onion has some prominent characteristics over other frameworks, such as being easily memorable, understandable, simple, and applicable for a broad range of research in different disciplines and fields. Therefore, the research onion will be used in this thesis, shown in Figure 2.1. The methodology will be done by "peeling off" each layer of the research onion by starting with the research approach done by deduction. This will be followed by the research strategy, where case studies and aspects from design science research will be applied. Afterwards, the research design is determined as single-case and cross-sectional, followed by the research method: data collection through interviews, literature review, and observations.

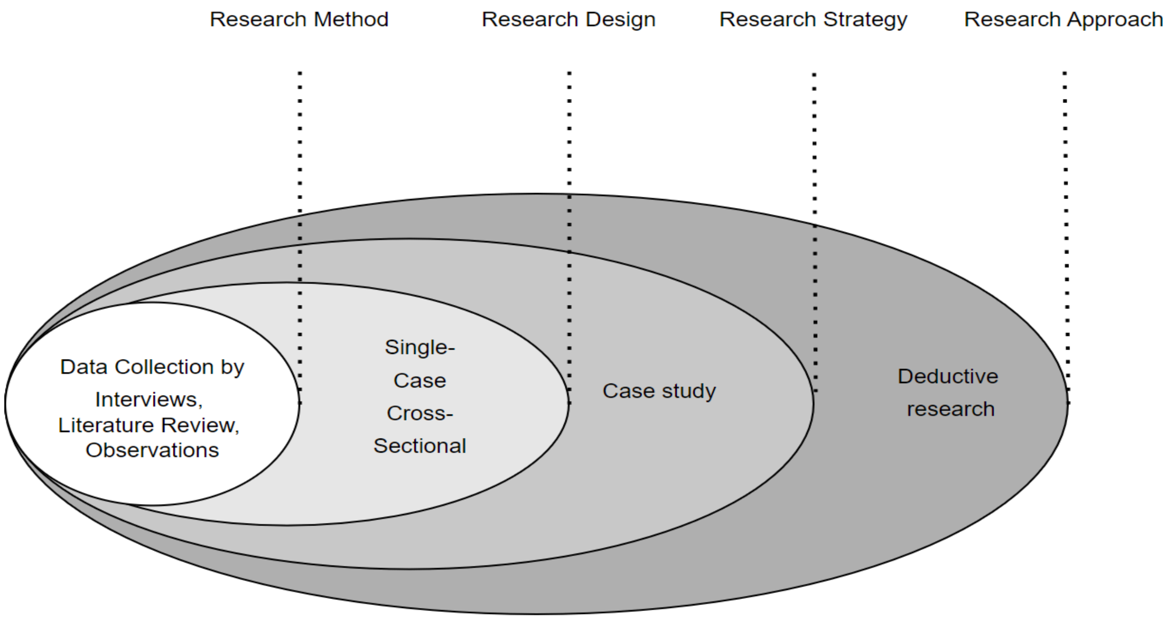

Figure 2.1: The methodology and method of the research (adapted from Saunders, Thornhill and Lewis (2019).

2.1 Research Approach

When a research project is conducted, it is ordinarily concerned with the testing or building of a theory, which raises the important issue of finding a suitable design for the research project. According to Saunders, Thornhill, and Lewis (2019), the issue can be seen as how to approach the research in terms of reasoning, which is described by three approaches: deductive, inductive, and abductive. Deductive research requires starting with theory, developed by reading academic literature and designing a research strategy to test the theory. The inductive approach collects data at first to explore a phenomenon and build a theory around that collection, which could be in the form of a conceptual framework. The abductive approach requires collecting data to explore a phenomenon, explain patterns, and identify themes to generate a new or adjust an existing theory, which is tested through additional data collection.

Okoli (2021) confirms that deductive theorising starts with a supported theory, ideally resulting in a new, supported, or enhanced theory. Inductive theorising starts off with non-theoretical empirical phenomena that should ideally result in a supported theory. Lastly, abductive theorising should start off with a theory-in-progress that ideally results in a proposed or supported theory. So, defining the three approaches is significant when starting the research and justifying which one or a combination of these is chosen.

Because of this, several researchers have delved deeper into understanding the research approaches and which approach seems fit for the research, as shown in Table 2.1. This thesis will start off with literature research and does not include data collection to identify themes and create a conceptual framework. It rather searches for general information about inbound logistics and translates that to a specific problem that the company experiences. However, data will be collected from the company to explore a certain phenomenon, which will be supported and analysed by data found within the literature framework.

Moreover, the prior theory has a significant role in this research. This being stated, the role of theory within this research is especially directive and informative because the literature will be applied to collected data and other theories, which makes the role of prior theory relevant. This role of theory is also related to the level of abstraction and the kind of environment in which the research will take place. The level of abstraction will be both concrete and abstract because the data will be collected from observations and largely from literature. As shown in Table 2.1, background factors will be controlled and explored within the study environment. Therefore, the information provided by Table 2.1 and previously described research conclude that the research approach for this thesis will be largely deductive and slightly abductive due to data collection within the research supported by a theoretical framework.

Table 2.1: Research approaches and aspects.

Sources	**Aspects**	**Deduction**	**Induction**	**Abduction**
(Janiszweski and Van Osselaer, 2021)	Objective	Test theory	Identify regularities in data	Propose original theory
(Marchiori, 2018; Saunders, Thornhill and Lewis, 2019)	Logic	In a deductive inference, when the premises are true, the conclusion must also be true	In inductive inference, known premises are used to generate untested conclusions	In an abductive inference, known premises are used to generate testable conclusions
(Marchiori, 2018; Saunders, Thornhill and Lewis, 2019)	Generalisability	Generalising from the general to the specific	Generalising from the specific to the general	Generalising from the interactions between the specific and the general
(Marchiori, 2018; Saunders, Thornhill and Lewis, 2019)	Use of data	Data collection is used to evaluate propositions or hypotheses related to an existing theory	Data collection is used to explore a phenomenon, identify themes and patterns and create a conceptual framework	Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this
(Marchiori, 2018; Saunders, Thornhill and Lewis, 2019)	Theory	Theory falsification or verification	Theory generation and building	Theory generation or modification: incorporating existing theory when appropriate to build new theory or modify existing theory
(Janiszweski and Van Osselaer, 2021)	Role of prior theory	Directive	Irrelevant	Informative
(Janiszweski and Van Osselaer, 2021)	Level of abstraction	Abstract; constructs	Concrete: observable variables	Abstract & concrete: observed variables inform proposed relationships between constructs
(Janiszweski and Van Osselaer, 2021)	Study environment	Control background factors	Ignore background factors	Explore background factors

2.2 Research Strategy

When doing scientific research, there are several things that need to be considered, Dresch, Lacerda and Antunes (2015) have exemplified some. Firstly, the chosen methodology should address the research question. Secondly, the methodology must be acknowledged by the research community. Thirdly, the methodology should follow the procedures for the research being done. The reason for this is to increase the validity and results of the research. Additionally, it should be mentioned that Dresch, Lacerda, and Antunes (2015) do not disregard the possibility of combining different methodologies, which can be done if they see fit. Lastly, Dresch, Lacerda, and Antunes (2015) present different characteristics of the three methodologies: case research, action research, and design science research, as seen in Table 2.2.

Table 2.2: Characteristics of design science research, case study, and action research adopted from (Dresch, Lacerda and Antunes, 2015).

Characteristics	Design Science Research	Case study	Action research
Objectives	Develop artefacts that enable satisfactory solutions to practical problems. Design and recommend	Assist in the understanding of complex social phenomena Explore, describe, explain and predict	Solve or explain problems of a given system by generation of practical and theoretical knowledge Explore, describe, explain and predict
Main activities	Define the problem Suggest Develop Evaluate Conclude	Define conceptual structure Plan the case Conduct pilot Collect data Analyse data Generate report	Plan actions Collect data Analyse data and plan actions Implement actions Evaluate results Monitor
Results	Artifacts (Constructs, models, methods instantiations) and improvement of theories	Constructs Hypothesis Descriptions Explanations	Constructs Hypothesis Descriptions Explanations Actions
Type of knowledge	How things should be	How things are or how they behave	How things are or how they behave
Researcher's role	Builder and/or evaluator of the artefact	Observer	Multiple, due to action research type
Empirical basis	Not mandatory	Mandatory	Mandatory
Researcher to research'd collaboration	Not mandatory	Not mandatory	Mandatory
Implementation	Not mandatory	Not applicable	Mandatory
Evaluation of results	Applications Simulations Experiments	Comparison against the theory	Comparison against the theory
Approach	Qualitative and/or quantitative	Qualitative and/or quantitative	Qualitative

Specificity	Generalisable to a certain class of problems	Specific situation	Specific situation

Furthermore, Yin (2018) mentions that the connection between the purpose and research strategy is very important when choosing a strategy. Therefore, Yin (2018) designed a table to answer the question of which research method is more appropriate than others by answering different questions and determining how the research questions are formed. It should be noted that Table 2.3, which was made by Yin (2018), contains only some research methodologies, as it does not contain some of the methodologies from Table 2.4, for example.

Table 2.3: Relevant situations for different research methods adopted from (Yin, 2018).

Method	Form of Research Question	Requires Control Over Behavioural Events	Focuses on Contemporary Events
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival Analysis	Who, what, where, how many, how much?	No	Yes/no
History	How, why?	No	No
Case Study	How, why?	No	Yes

Saunders, Thornhill, and Lewis (2007) further build upon the importance of choosing the correct research strategy by choosing the method that will allow the best answer to the research questions instead of focusing on picking a specific strategy. Therefore, the choice of strategy will be decided through the research questions rather than the other way around. Furthermore, Saunders, Thornhill, and Lewis (2007) mention that research strategies can be combined. Additionally, by including a third author and their description regarding different research methods, a table is provided to conclude the research methods described by Saunders, Thornhill and Lewis (2007) and their view. Table 2.4 provides several research methods that could be used for this research and possibly be seen as a good fit for the project.

Table 2.4: Different research methods adopted from Saunders, Thornhill and Lewis (2007).

Method	Objective	Description
Experiment	By answering the “how” and “why” questions in an exploratory and explanatory experiment	Studying causal links between variables
Survey	By answering the ‘’who’’, “what”, “where”, “how much”, and “how many” questions in an exploratory and descriptive research	A method used to collect a large amount of data in a highly economical way from a sizable population
Case study	By answering the “why”, “what”, “how” used in an explanatory and	An empirical investigation of a phenomenon within its real-life

	exploratory research	context using sources of evidence
Action research	By answering the “how” questions with a focus on change, diagnosing, planning, taking action and evaluating the process	Research is concerned with the resolution of organisational issues of who experience these issues together or directly
Grounded theory	By exploring the wide range of business and management issues through a combination of induction and deduction by theory building	The research provides a prediction and explanation of behaviour with an emphasis on developing and building a theory
Ethnography	The purpose is to describe and explain the social world in a way that research subjects would describe and explain it	Researching the naturalistic phenomenon within the provided context where data does not oversimplify the complexities of everyday life
Archival research	This research allows research questions which focus on the past to be answered in an exploratory, descriptive or explanatory way	This research makes use of administrative records and documents as the principal source of data in order to research the past

Upon comparing these methods systematically and following the advice of multiple authors, by analysing the characteristics in regards to our research questions, “How could goods be received from suppliers and managed at the receiving warehouse depending on item characteristics?”, “What does the current situation of Boozt's inbound look like?”, “How do the suppliers perform compared to each other for Boozt?” and “What should the relationship look like between Boozt and their Suppliers?”. It is believed that following the methodology structure of a single case study is the most appropriate to answer our research questions in this thesis. However, it is also seen as beneficial to borrow aspects from design science due to the benefits that it brings, such as the restriction regarding case research that restricts to only understanding and assisting the phenomenon that is being researched. Additionally, design science research allows for recommendations to be given that will enable solutions to problems. However, an evaluation afterwards is not being done, which leads to the design science research not being fully utilised. Lastly, the type of knowledge that both design science research and case studies research contain will be investigated. Therefore, this thesis will be a case study combined with aspects of design science, which will be further discussed in the sections below.

2.2.1 Unit of Analysis

Within the research design, the unit of analysis is emphasised as very important. Unit of analysis can be defined as the “entity that is being analysed in a scientific research”. Only a closer look at complex studies can identify the unit of analysis where aspects such as variables, data analysis techniques, and all other elements of scientific research affect the unit of analysis (Dolma, 2009). According to Dolma (2009), several categories, such as individual, group, and organisational levels, are described, and the group level depicts the unit of analysis within our research. The main focus of the research consists of multiple departments with multiple individuals within Boozt's inbound logistics. Therefore, the unit of analysis focuses on the group level where Boozt's inbound logistics processes are being researched and analysed, with the warehouse and inbound logistics departments being involved.

2.2.2 Case Study Strategy

A case study is “an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Yin, 2009). Additionally, when choosing this strategy, there has to be a choice between a single case study and a multiple case study (Farquhar, 2012; Voss, Tsikriktsis, and Frohlich, 2002). The choice between these is not without advantages and disadvantages.

A single case study usually has greater depth. However, there are limits to the generalisability and biases that may be involved. A multiple case study has greater validity and less bias, but these require more resources and are usually not as in-depth (Voss, Tsikriktsis, and Frohlich, 2002). This study will specifically research Boozt’s inbound logistics. Therefore, this thesis will be a single case study.

Furthermore, a case study uses data collection methods such as interviews and/or surveys, which will also be implemented in this research (Farquhar, 2012). Another important aspect that must be kept in mind is ensuring the reliability and validity of this type of research. This is mainly due to this being one of the aspects that case-based research is criticised for (Stuart et al., 2002). This is also mentioned by several authors and further emphasised by (Farquhar, 2012) and (Voss, Tsikriktsis and Frohlich, 2002). They also suggest measures to take in order to ensure these aspects of the report which will be discussed.

2.2.3 Design Science Research

Design science research (DSR) can be defined as an application that follows the CIMO logic where this logic involves a problematic Context (C), a suggested Intervention type (I), to provide, through activated Mechanisms (M), certain Outcomes (O). The DSR provides an analysis that includes explanations and specifications for interventions to improve the effectiveness of organisations in their daily practices (Denyer et al., 2008). The generic design of DSR explores new approaches to certain issues within organisations without leading to well-defined designs. This design, where action/outcome is combined with explanatory mechanisms, can be seen as a mid-range theory between case-specific and universal. By following these mechanisms, a basic pragmatic logic can be followed: if achieving Y in situation Z, then use the design X or perform X to achieve Y in situation Z (Van Aken et al., 2016).

Figure 2.2 shows the functioning of design science research, where the organisation structure and the sort of industry involved give the context. The whole model depends on the context where interventions, mechanisms, and outcomes are found. Certain interventions trigger mechanisms such as learning and validation that lead to soft, average, and top-hard outcomes. This model explains how the DSR operates and functions within particular aspects of the research.

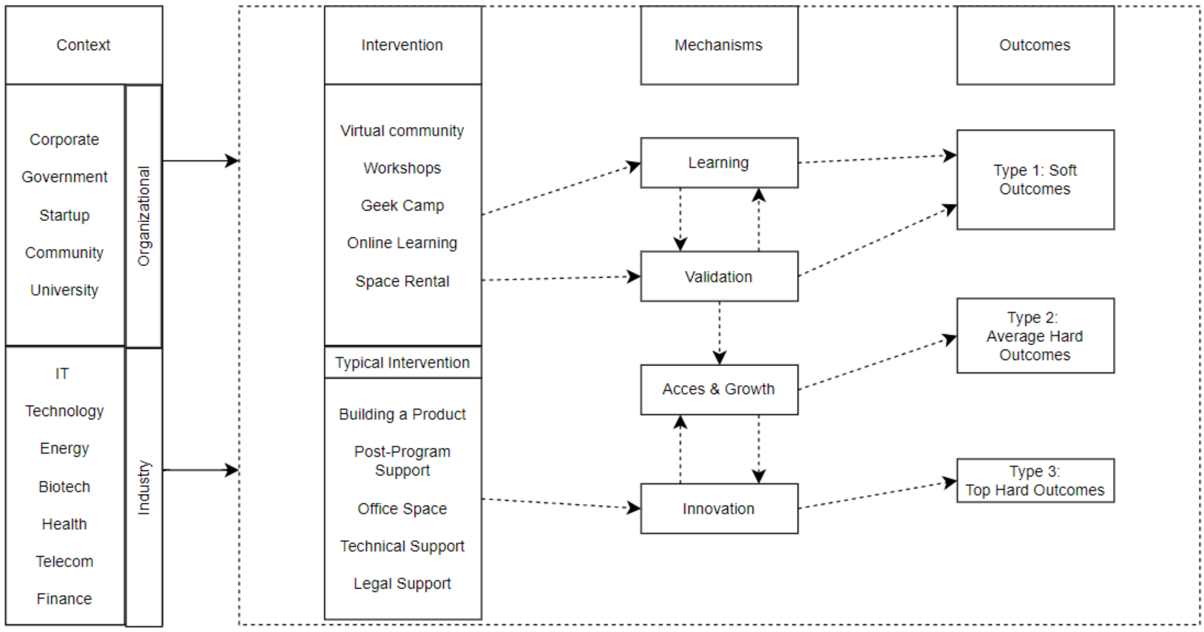

Figure 2.2: The Design Science Research Model adapted from Crișan et al., (2019).

Thus, DSR is a method focused on problem-solving, which can be used to transform situations by changing their conditions to a more desirable state. The application of DSR can reduce the gap between research and the requirements of organisations. However, the focus groups are significant and can generate new possibilities and obtain better solutions where either way within DSR, exploratory or confirmatory focus groups are used (Dresh et al., 2014). The challenges within this research lie in locating and integrating information sources from many fields where DSR offers an appropriate mechanism for the problem and helps to overcome challenges regarding difference and diversity (Denyer et al., 2008).

2.3 Data Collection

A solid data collection process was necessary to conduct the master's thesis, answer the research questions, and deliver a result to the company. Furthermore, data collection can be split up into two main categories: primary sources and secondary sources. Primary sources consist of interviews and observation, essentially where the person gathers firsthand data. Meanwhile, secondary sources can include, for example, government publications and research articles, which are considered second-hand information (Kumar, 2010).

Furthermore, Yin (2018) mentions that there are six sources of data collection that are commonly used in case studies: documentation, interviews, archival records, physical artefacts, participant observation, and direct observations. Figure 2.3 shows an example of what these different data collection methods can contain.

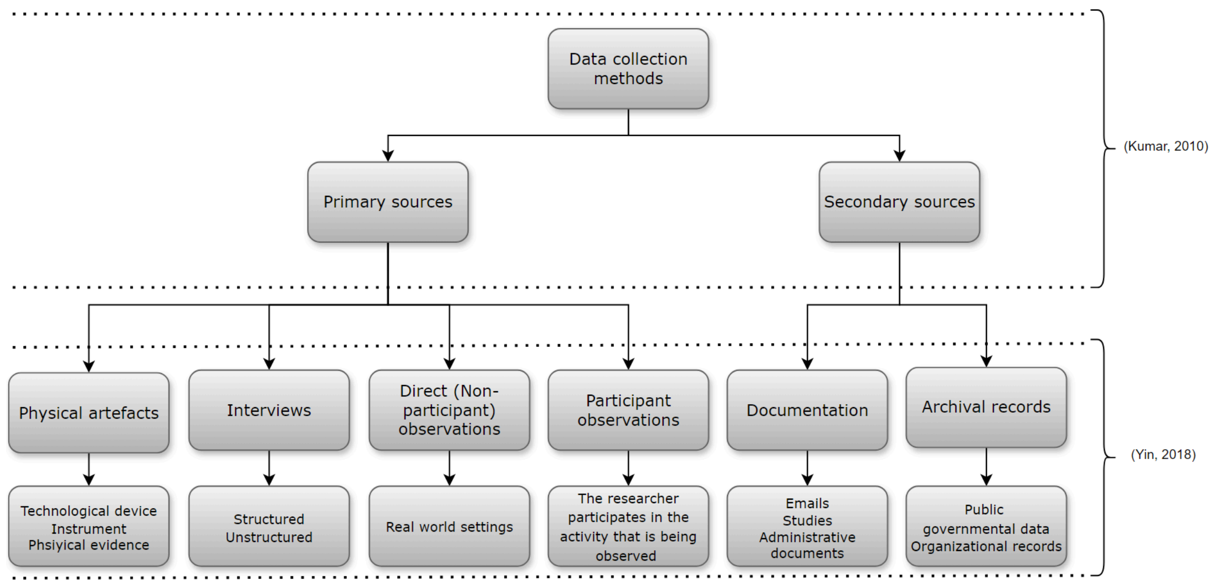

Figure 2.3: Framework of some data collection sources and some of the examples within them, adapted from a combination of Yin (2018) and Kumar (2010).

When conducting this master's thesis, internal documents from the company were given, observations were made, several interviews were organised, and extensive literature research was carried out. Furthermore, the company's observations were also considered when carrying out the empirical chapter. Lastly, the following sections will discuss a more detailed description of the methods used.

2.3.1 Literature Review

The literature review was achieved using different examples within the documentation data collection method. According to Yin (2018), documentation can play an important role in the overall data collection while conducting case study research. A literature review is essentially an overview and critical review of existing literature that is already available (Jesson, Matheson and Lacey, 2011; Rowley and Slack, 2004). Furthermore, one of the important aspects to keep in mind while conducting the literature review is to keep it narrow and focused on the topics instead of taking a more comprehensive approach (Rowley and Slack, 2004). Furthermore, Jesson, Matheson, and Lacey (2011) mention that there are two different styles of literature review: traditional literature review and systematic review. The traditional literature review is essentially what was previously described, with the addition of what issues the authors may find important to raise. A systematic review follows six steps in order to qualify as such. These steps are;

1. Define the research question
2. Design the plan
3. Search for literature
4. Apply exclusion and inclusion criteria
5. Apply quality assessment.
6. Synthesis

If the literature review did not follow these six steps precisely, it can not be counted as a systematic review. However, the literature review may still have been conducted methodically and not randomly, but this does not qualify as a systematic review. One reason to do a systematic review is that it is a more neutral and standardised process than the traditional literature review. Additionally, either approach should have a clear research question to keep the literature review focused (Jesson, Matheson, and Lacey, 2011).

Lastly, Rowley and Slack (2004) mention that there are several ways to enter when searching for specific literature. Two of these that were applied in this master's thesis are

- Citation pearl growing
- Successive fractions

The Citation pearl growing strategy is when one document or a couple of documents have been used, followed by more relevant literature that is retrieved by using keywords within the papers, which is essentially backtracking in a way. Successive fractions are used when many documents are available that were retrieved from a search of keywords. Within this search, the papers are narrowed down by including further sub-words and making them more detailed when searching (Rowley and Slack, 2004).

In this master's thesis, the literature review follows a more traditional literature review approach. The searches were not entirely random but had some structure. However, this is not enough to qualify it as a systematic review. As mentioned, both the citation pearl growing and successive fractions were used. At the start of the research, successive fractions were applied by narrowing down the searches such as "inbound e-commerce" to "inbound logistics in e-commerce" or "E-commerce Supplier evaluation" to "E-commerce Ahp supplier evaluation". Furthermore, citation pearl growing was applied throughout the literature review, for example, in Chapter 3.4, the keywords "warehouse operations in e-commerce" were used to find the first sources, and from there, several related sources of literature were found through suitable search terms within them. Finally, all the literature was gathered from search engines such as Scopus, Google Scholar and Lubsearch.

2.3.2 Interviews

An interview is a discussion with a certain purpose between at least two people, where the goal is to help achieve data and information that will help answer the research questions (Saunders, Thornhill and Lewis, 2007; Voss, Tsikriktsis and Frohlich, 2002). The interview consists of the interviewer asking and reading the questions verbally to the interviewee while the interviewer takes notes or records the meeting (Kumar, 2010). Interviews are one of the most important data collection methods for a case research study (Yin, 2018; Voss, Tsikriktsis and Frohlich, 2002). Much of the data gathered in the empirical chapter is mostly collected through interviews. However, since the results of the interviews are also dependent on the interviewers' skills, this also plays a role in the outcome. Some qualities that a good interviewer should have are good listening and interpretation skills, good questions and flexibility (Saunders, Thornhill and Lewis, 2007; Voss, Tsikriktsis and Frohlich, 2002). Voss, Tsikriktsis and Frohlich (2002) also point out that even though an interview usually only has one interviewer asking the questions, there can be benefits to having multiple interviewers. For example, one interviewer may exclusively take the interview notes while the other person asks the questions and collects the data, which will lead to increased chances of accuracy.

Kumar (2010) mentions that there are several different types of interviews, and they are all dependent on the level of formality and flexibility, however, on one side of the spectrum, there are unstructured interviews, and on the opposite side, there are structured interviews. The unstructured interview is not formal; there is a lot of freedom to decide what to explore in the discussion, and there is no proper structure. The questions do not need to be predetermined, and new ones are allowed to appear during the interview (Kumar, 2010; Saunders, Thornhill and Lewis, 2007). The structured interviews are formal and are based on predetermined questions while being consistent with the wording of the questions. Furthermore, the questions are to be read out using the exact same words and order as written on the question sheet (Kumar, 2010; Saunders, Thornhill and Lewis, 2007). Between these two types, Saunders, Thornhill, and Lewis (2007) mention semi-structured interviews as a form of interview. This interview will have predetermined questions to be covered, however, deviations from these are allowed, and the order of the questions can also be changed. Lastly, additional questions are fine to allow for a deeper discussion.

When the type of interview is decided upon, each type has its own focus. For example, each type can be described as more exploratory, explanatory, or descriptive. Table 2.5 compares the three types of interviews.

Table 2.5: Focus areas for the three different types of interviews, adopted from Saunders, Thornhill and Lewis (2007).

	Exploratory	Descriptive	Explanatory
Structured	Not frequent	More frequent	Less frequent
Semi-structured	Less frequent	Not frequent	More frequent
Unstructured	More frequent	Not frequent	Not frequent

In this thesis, the interviews will be semi-structured due to the adaptation it allows while maintaining a structure. It allows for follow-up questions if there are aspects that need to be delved deeper into, as well as changing the order if needed for the flow of the discussion. All interviews, except interview 1, followed the same procedure. The interviewees were sent a list of the predetermined questions a couple of days before each interview. Then, one interviewer was mainly assigned to take notes during the interview while the other led the interview. The predetermined questions were adjusted depending on the person's job position. After the interview, both interviewers sat down together and went through the information gathered to see if anything was misinterpreted or missed. Lastly, if further questions were missed during the interview, follow-up questions were mailed instead of conducting a new interview. In Table 2.6, a list of the interviews containing their position, location, duration and date can be found, and in Appendix A, the interview questions can be found.

Table 2.6: List of interviews.

Interviewee	Job Position	Location	Date, Duration
Interview 1	Chief Supply Chain Officer	Malmö	2023-12-15, 45 minutes
Interview 2	Logistic Project Manager and Production Manager Inbound	Ängelholm	2024-03-04, 60 minutes
Interview 3	Supply Chain Director	Malmö	2024-03-18, 60 minutes
Interview 4	Logistic Project Manager and Production Manager Inbound	Ängelholm	2024-04-03, 30 minutes
Interview 5	Buying Director	Malmö	2024-04-05, 60 minutes

2.3.3 Observations

Observations are essentially a method where a person watches, listens, analyses, and interprets a phenomenon or interaction (Kumar, 2010; Saunders, Thornhill and Lewis, 2007). There are two main types of observations: participant observation and non-participant observation (Kumar, 2010). According to Kumar (2010), Mazhar et al. (2021), and Saunders, Thornhill and Lewis (2007), participant observation is when the researcher decides to participate in the activities of the people being observed. This allows the researcher to share the experience of the group being observed. Non-participant observation is when the researcher does not perform the different activities being observed but is passive and only watches, follows, and listens, drawing different conclusions (Kumar, 2010). According to Yin (2018), some examples that involve non-participating observation are passively observing things such as meetings, factory work and classrooms. In this thesis, only non-participant observations have been made, which are presented in Table 2.7.

Table 2.7: List of observations.

Observations	Interactions observed	Description of the observations	Location	Date, Duration
1.	Warehouse operations	Tour of the warehouse while looking at the different processes that exist.	Ängelholm	2024-03-04, 120 minutes
2.	Warehouse operations	In-depth tour of the warehouse mainly focused on explaining the inbound flow specifically	Ängelholm	2024-04-03, 90 minutes
3	Warehouse operations	Full day at the warehouse observing the different inbound operations as well as timing the different processes which are used for the value stream map. For example, the time it took to	Ängelholm	2024-04-23, 300 minutes

		take out pallets from the trucks arriving on to the inbound area was observed and timed. Also, an in-depth explanation of the Sorting/VAS process was done.		

2.4 Credibility of the Study

The data collection processes can have an effect on the quality of the conclusions taken when conducting a research project. Therefore, this is important to look into (Kumar, 2010). According to Saunders, Thornhill and Lewis (2007), research credibility aims to reduce the possibility of getting the research questions wrong. This is because there is never a hundred per cent assurance that the answers that have been concluded will be correct. However, to increase the possibility of this, there are two particular topics that have to be discussed: validity and reliability.

2.4.1 Validity

The validity of research is defined by how accurately a concept is measured in a quantitative study. According to Golafshani (2003), validity determines if the research truly measures what was intended by the researchers and how truthful the results are. This is done in general by asking a series of questions, which are often looked at by the research of others to get those answers. There are three types of validity, which are content, construct and criterion validity that are used in a way to accurately measure if all the aspects of a construct and intended construct are valid by using a research instrument that is related to other instruments to measure the same variables (Ahmed and Ishtiaq, 2021; Heale and Twycross, 2015). According to Ahmed and Ishtiaq (2015), in order to assess validity, internal and external validity are to be considered to measure how accurately and precisely the reference sample obtains the results. The validity of the research depends on three aspects described in the article. Firstly, validity is ensured by selecting a high-quality technique to measure data based on existing or latest knowledge. This is done, for example, by sending out a questionnaire based on theories from previous studies that have to be worded carefully and precisely. Secondly, the sampling methods should be fitting for the sample selection. Thirdly, the subjects or parameters should be clearly defined, and the sample size should be representative of the population, procedure or parameter. However, Taylor (2013) states that there are threats to validity that lead to doubt whether the research and assessment can be trusted. Therefore, in the final assessment of validity, the connection between the results and the intended construct, the usefulness of the results for the given purpose, and the social consequences of inferences and actions based on test scores have to be assessed.

Within this master's thesis, these assessments and threats must be constantly considered while collecting data and conducting research. This way, the validity of the research will be maintained throughout the whole process, and a series of questions will constantly be used to ensure the truthfulness and intention of the research.

2.4.2 Reliability

Reliability is the ability to allow for your analysis and data collection to be repeatable, as in if someone follows the same steps, then the results should come out the same (Saunders, Thornhill and Lewis, 2007; Voss, Tsikriktsis and Frohlich, 2002; Yin, 2018). Furthermore, Yin (2018) states that the aim of reliability in a research study is to minimise the biases and inaccuracies, the higher the reliability. Some aspects that affect the reliability could be how the questions are phrased, for example, the questionnaire or interview, the physician environment and the mood of the interviewer(s) and interviewee (Kumar, 2010). Additionally, Saunders, Thornhill, and Lewis (2007) state that there are four threats to reliability in research: subject or participant bias, subject or participant error, observer error, and observer bias. Subject or participant bias is, for example, when the person being interviewed may only say things their superiors want them to say, resulting in them not giving reliable answers. A way to alleviate this would be to ensure confidentiality and be extra critical when analysing the data. Subject or participant error happens when research is being done on extremities such as happiness on a Friday afternoon compared to Monday morning. Therefore, this should be to choose the participating people when the atmosphere is as neutral as possible. Observer error occurs when there are very few systematic procedures, similar to the aspect Kumar (2010) pointed out regarding the wording of questions. Lastly, observer bias regarding the interpretation of the data and their own opinions may play a factor here (Saunders, Thornhill and Lewis 2007).

In this master's thesis, supervisors at Lunds Tekniska Högskola and the company will review the contents to minimise potential biases and errors. Furthermore, two seminars will be held where students will oppose the thesis, and they will do the same. Lastly, both authors will review the data gathered together and individually, which should reduce the risk of bias.

3. Theoretical Framework

This chapter includes literature research, which provides a deeper understanding of inbound logistics and the literature required to solve the problem. The chapter describes the supply chain management of inbound logistics and how these can be mapped. Thereafter, supplier relationship management is highlighted, together with certain tools and frameworks used to evaluate this. Lastly, warehouse operations are researched, and the processes, policies, and equipment are outlined.

3.1 Supply Chain Management of Inbound Logistics

Supply Chain Management (SCM) can be defined in many ways, Shivaditya, Seth and Tyagi (2016) mention one of the definitions is “Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities.”. Meanwhile, (Muñoz-Villamizar et al., 2021) bring up that the goal of SCM is to minimise inventory and linked costs while meeting the objectives for customer service.

In this chain, inbound logistics focuses on the processes that involve transporting and delivering materials from suppliers into either a warehouse facility or other business processes (Vitasek, 2013). Compared to the other parts of the supply chain, this means there needs to be some form of relationship between the companies and the suppliers to make this function (Muñoz-Villamizar et al., 2021).

The challenges associated with shorter delivery times due to market requirements are numerous, creating a massive challenge for inbound logistics. These challenges could include procurement policies that require change, inventory management, higher costs due to sped-up shipping, not using full truckloads, which will also add to costs, and increased CO_2 emissions (Muñoz-Villamizar et al., 2021).

According to Shivaditya, Seth, and Tyagi’s (2016) Delphi study, 16 important parameters monitor the efficiency of inbound logistics. However, the most important dimensions that were decided on were cooperative planning and trust between the supplier and company, on-time orders with no logistic service failures, level of coordination, order fill rates and demand forecasting capabilities. These parameters can be seen as important goals to perform well in order to achieve an efficient inbound logistics system in the e-commerce area, lower costs, increase inventory, and increase responsiveness.

3.2 Mapping of the Supply Chain

Mapping the supply chain is an important aspect of understanding the organisation's supply chain. A map is basically a representation of how the setting looks, which then is broken

down and simplified, however, the main focus should be to keep the representation of the processes as accurate as possible when designing the supply chain map
(Gardner and Cooper, 2003). Mapping the supply chain has several advantages and disadvantages, shown in Table 3.1.

Table 3.1: Advantages and disadvantages of mapping.

Advantages (Gardner and Cooper, 2003)	Disadvantages (Farris, 2010)
• Allows for easier planning • It is a good tool for communicating information internally and externally • Makes it easier to see where changes may be needed as well as identify areas where a deeper analysis may be needed • A good tool for when an evaluation and analysis needs to be made. • May locate bottlenecks in the system • Is great to present both the descriptive and possible prescriptive situation • The process of creating the map will lead to a better understanding of the supply chain. • Easier for new employees or members to be educated and given their role in the supply chain • It can lead to continuous improvement within the supply chain, and one key element of continuous improvement is having documented processes, which mapping brings.	• Possible to make the map too complex, which may result in counteracting the purpose of the map • It can very quickly get too complex due to, for example, including a supplier's supplier in the map as an exponential function • The temptation to include unnecessary data just due to it being available

Lastly, it should be mentioned that there is no correct way to develop a supply chain map. There are defined processes; however, these processes also involve a subjective approach, and the design may be adjusted depending on the situation. There are aspects to what a good map should include (Farris, 2010).

3.2.1 Value Stream Mapping

One way to systematically map the activities of a company is by using value stream mapping (VSM). It comes from the lean methodology and is a tool used to evaluate and measure the different activities, such as the information and material flow. The goal of the tool is to reduce the non-value-added activities in a company, this is done by making it easier to identify where there are losses in each process. It was mainly designed as a tool for the manufacturing industry; however, several papers have applied this tool in different areas to achieve improvements (Qin and Liu, 2022).

According to Qin and Liu (2022), VSM shares the same core idea that any organisation wants. This is because VSM is one way to map the process and analyse the activities while driving improvement. They also state that the main idea of lean production is to maximise customer value while keeping waste to a minimum, which is aligned with the same goals as any supply chain. Therefore, applying it to an e-commerce situation should not be far-fetched (Qin and Liu, 2022).

The VSM tool consists of five different steps that must be completed. These five steps are:

- Deciding on the area where you will look at the value stream
- Make a map of the as-is situation
- Make a map of the to-be situation
- Create the implementation plan while deciding on who, what and when
- Implementing the plan

(Langstrand, 2016)

Certain symbols are standardised for creating a map. However, custom ones can also be used if required. The as-is map is created with these symbols, shown in Figure 3.1 for certain symbols, and Figure 3.2 shows an example of the map.

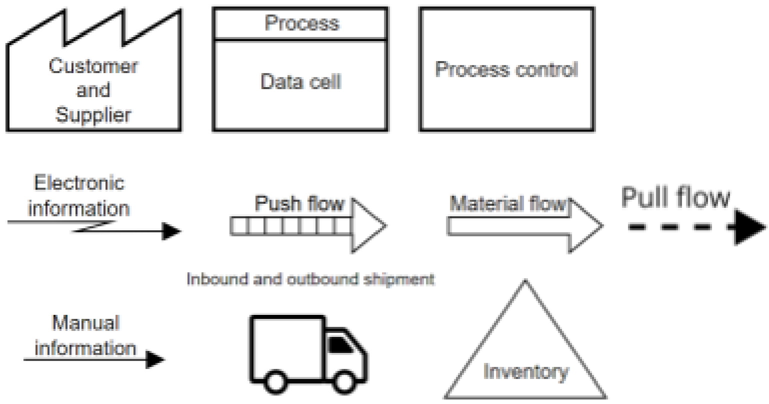

Figure 3.1: Example of VSM symbols adapted from Langstrand (2016).

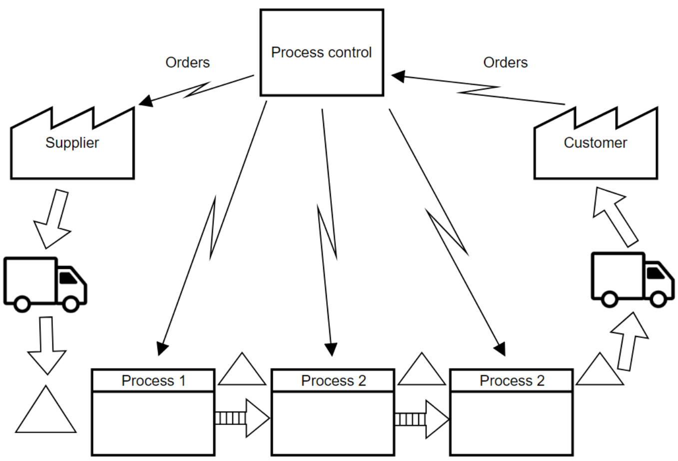

Figure 3.2: VSM example adapted from Qin and Liu (2022).

According to Langstrand (2016), once the value stream as-is map is complete, the first step is to analyse the flow and see if there is a balance between the start and finish. This version of the map also allows for the identification of different wastes. These wastes are aspects such as overproduction, overprocessing, inventory, unnecessary movements, waiting times, transportation and defects, which are based on lean principles (Hartel, 2022).

Once this is done, it should allow for a better picture of the whole value chain and bring forward ideas for improvement that are to be implemented. These ideas are then put in when creating the final as-is map to see how the new process will look before working on the implementation plan (Langstrand, 2016).

3.2.2 Swimlane Diagram

A swimlane diagram can also be referred to as a cross-functional process map, the reason for the name is due to how the design looks from a top view, whereas it looks like swimming pool lanes (Damelio, 2011; João, 2018). It can both be used to describe the as-is flow as well as a way to show the to-be flow. Either way, it is meant to be used as a form to display the company process from start to finish and to help understand this process better (Sharp and McDermott, 2009). The area the diagram should cover is up to the person that maps it, it can either be the whole company or certain departments and also in detail, such as individual tasks (Gadatsch, 2023; João, 2018; Sharp and McDermott, 2009). According to Damelio (2011), there are several reasons to use a swimlane diagram, one of these is that it is a good way to show where in the company a work activity takes place and, at the same time, show the type of work. Another reason Damelio (2011) mentions is that it helps make the relationship between the organisation and their customers more visible. In order to design a swimlane diagram, Gadatsch (2023) says that the process steps are to be shown as rectangles, and the different decisions that have to be made are presented as diamonds. Sharp and McDermott (2009) also mention that the sequence of the flow is done from left to right based on the time it is done. Furthermore, to reduce the complexity, the standard path is often only modelled, and exceptions or special cases are not included (Gadatsch, 2023). Finally, an example of a basic swim lane diagram is presented in Figure 3.3

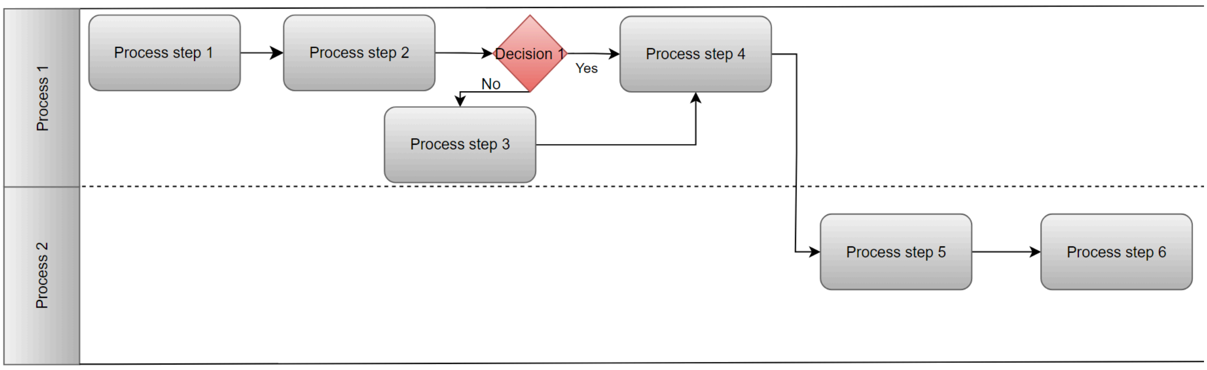

Figure 3.3: Basic swim lane diagram using the diamond and rectangle symbols adapted from Gadatsch (2023).

3.3 Supplier Relationship Management

Supplier Relationship Management (SRM) is among the most important aspects of supply chain management. The term SRM is basically the process that oversees all the agreements, contracts, coordination, collaboration and information sharing between the company and the suppliers (Putra, Tarigan and Siagian, 2020). The purpose of SRM is to achieve mutual benefit for each side. Then SRM will result in benefits such as faster acquiring the products, making the processes more effective and better managing the inventory (Sharif, et al., 2014) Putra, Tarigan and Siagian (2020) state that there are many benefits to SRM such as increased product life cycle, product quality improvement and greater adaptability to customer preference, reduced costs. Tidy, Wang and Hall (2016) also mention sustainability improvements as one of the benefits. According to Putra, Tarigan and Siagian (2020), SRM is a way to achieve success in strategic ways by having these relationships with key suppliers. However, the benefits for both parties can only be achieved if there is a collaboration based on a commitment from both sides with a long-term relationship as a goal. One of the ways to achieve this is demonstrated by Putra, Tarigan and Siagian (2020). The study shows that the quality from the suppliers to the retailer affects the relationship between the supplier and retailer. Therefore, the information quality must be high to satisfy the retailers and build a strong relationship. Whereas the study done by Sharif, et al. (2014) focused more on the communication aspects between the company and the supplier and found that face-to-face communication and different e-procurement technologies positively affect supplier relationships.

According to Tidy, Wang and Hall (2016), the key aspects of SRM are trust and communication. If these aspects are good, then this is often an indicator of a good SRM and vice versa, but if both sides instead focus purely on results, then this is more of a transactional approach to the relationship. It should be mentioned that several papers such as (Al-Abdallah, Abdallah and Hamdan 2014; Dash, Pothal and Tripathy, 2018; Moeller, Fassnacht and Kiose, 2006; Park, et al., 2010; Tidy, Wang and Hall 2016; Zairi and Al-Mashari 2002) mention trust as a major factor for achieving a good relationship between the company and supplier.

However, the type of relationship between the supplier and the organisation should not be the same for all suppliers. It depends on aspects such as the type of products, order frequency and supply risk (Moeller, Fassnacht and Kiose, 2006; Park, et al., 2010; Sharif, et al., 2014).

Park, et al. (2010) present a framework for what type of relationship to have with the suppliers depending on their strategic importance and relationship attractiveness. Additionally, a supplier development framework is constructed out of this, which guides how to treat the suppliers to improve their performance.

The framework in Figure 3.4 is created by combining the matrix from Kraljic's 1983 and the purchasing portfolio model from Olsen and Ellram 1997. Forming the x-axis with the portfolio model and, thereafter, forming the y-axis with the Kraljic matrix will create the relationship strategy model.

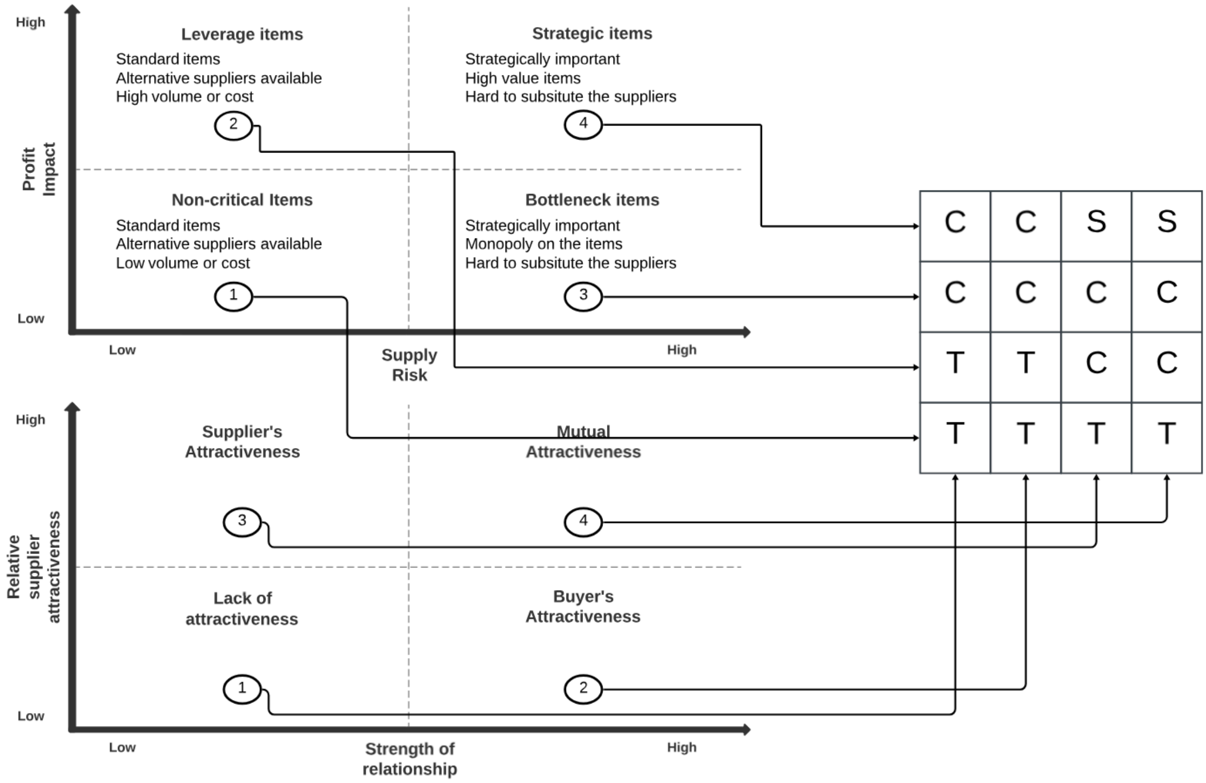

Figure 3.4: Framework for which type of buyer-to-supplier relationship to implement, adopted from Park, et al. (2010)

The factors describing the X-axis and strength of the relationship in the Olsen and Ellram model are economic factors, exchange relationship factors, cooperation factors and factors regarding the distance between the buyer and the supplier in aspects such as social, cultural, technological, time and geographic distance. The factors impacting the Y-axis relative supplier attractiveness in the model include financial, performance, technological, and organisational factors (Olsen and Ellram 1997).

Once the supplier has been positioned on these models, the type of relationship between the buyer and supplier is suggested. The relationships are divided into three types depending on where the supplier is placed on the axis. They can either be strategic (S), collaborative (C), or transactional (T), as shown in Figure 3.4 (Park et al., 2010).

Thereafter, the second framework, which is how to treat the suppliers for performance improvement, is constructed by the result of the relationship model. Each type of relationship forms the y-axis in the supplier treatment model. The X-axis is developed by the result of a supplier evaluation, depending on their performance, capability, and collaboration, whereas the supplier ranges from bad to good and excellent. This constructs the framework in Figure 3.5. The framework is divided into four groups: prime, improvement, collaboration and maintenance (Park, et al., 2010).

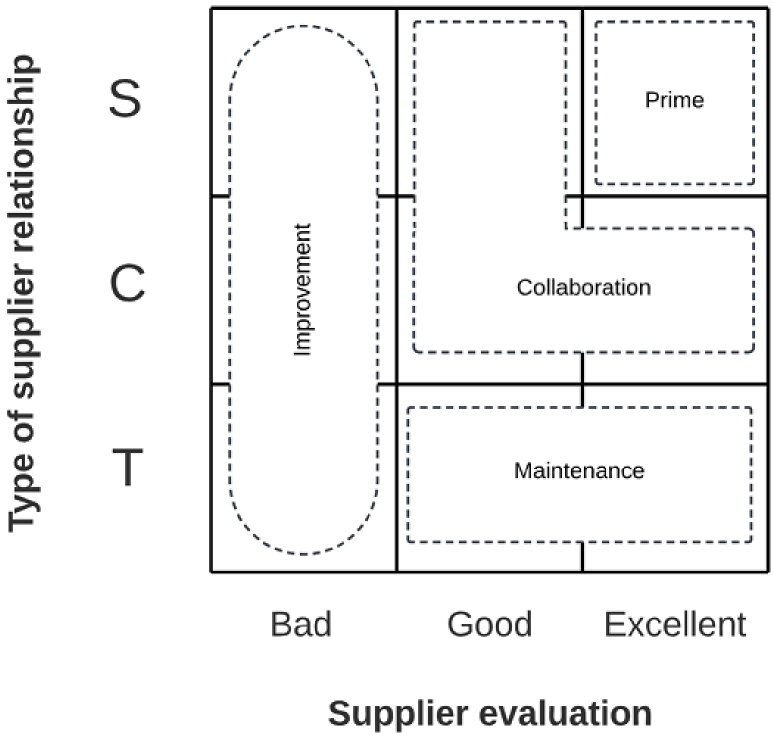

Figure 3.5: How to treat the suppliers for better collaboration and performance, adopted from Park, et al. (2010).

If the supplier is placed in the prime group, the steps should be to construct a long-term relationship with trust and provide them with strong incentives to stay. If the supplier is placed in the improvement group, then the company needs to be more strict in the way of performing supplier audits, inspections and improvement activities. If it is placed in any of the collaboration cells, then there has to be a focus on improving the current cooperation to further increase the mutual benefits between the organisation and the supplier. Lastly, if a supplier is placed in any of the maintenance cells, it calls for no change and to continue the current relationship the way it is (Park, et al., 2010).

3.3.1 Supplier Evaluation and Selection

Supplier evaluation and selection have been vital for several years. Structuring and selecting suppliers is a very important task within any organisation, especially with the current global purchasing of many companies. Gallego (2011) states that purchased goods and services account for more than 60% of the costs of goods being sold in many companies, and 50% of quality defects can be traced back to purchased material. This implies that many costs rely on the performances of the suppliers and how organisations select these suppliers.

The supplier evaluation can be described as measuring the efficiency and effectiveness of the supplier's performance. According to Hald & Ellegaard (2011), a three-phase supplier evaluation model can be adopted as a starting point where the design, implementation, and use of supplier performance systems are crucial for the evaluation. However, three main conclusions were drawn from the evaluation processes where, firstly, the majority of the suppliers did not feel accurately evaluated. Secondly, the evaluating organisation did not use the gathered information properly in the audit process. Finally, suppliers felt that being evaluated did not lead to improvement of the supplier's performance but rather being a good fit for the company's format.

Therefore, supplier selection requires multi-criteria decision-making (MCDM) models where various criteria are involved, including speed, delivery performance, price, quality, reliability, etcetera (Agarwal et al., 2011; Hald & Ellegaard, 2011; Zhang et al., 2020). Different researchers have utilised different MCDM techniques to effectively solve the problem of selecting suppliers. These MCDM techniques range from simple techniques, such as the Weighted Sum Model, to more complicated techniques, such as the Analytical Hierarchy Process (AHP), fuzzy approaches, and Data Envelopment Analysis (DEA) (Argarwal et al., 2011).

According to Hussain et al. (2017), all these MCDM techniques have common principles, and these principles are divided into three steps. First, a selection of criteria is made, which must be related to alternatives, well organised, and independent of each other. Secondly, a selection of alternatives is made where these selections must be real and available. Lastly, the method will be selected to provide weightage to the criteria, which can be either an outranking or compensatory method. An outranking method provides a series-wise comparison between alternatives, while the compensatory method relies on strengths and abilities over the weaknesses of the alternatives.

Within the MCDM area, the technique AHP has been applied by numerous researchers in selecting and evaluating suppliers of e-commerce companies (Ruskartina et al., 2023). Moreover, AHP is, besides being very popular within the literature due to simplicity, consistency, and flexibility, a technique that has been the most used technique by itself or in integration with other techniques compared to other MCDM techniques (Gallego, 2011; Kumar et al., 2019; Ruskartina et al., 2023). However, AHP is used to evaluate selection criteria, while ranking these criteria remains an issue. Therefore, the MCDM Technique For Order Preference by Similarity to an Ideal Solution (TOPSIS) has been utilised widely as a method that finds the closest to the ideal solution for the ranking of these criteria while maximising benefits and avoiding risk as much as possible (Kumar et al., 2019). For that reason, a hybrid of MCDM is suggested, including the techniques AHP and TOPSIS, which will be used to evaluate and select suppliers.

3.3.1.1 AHP

The analytical hierarchy process (AHP), created by Thomas Saaty, is one of the multi-criteria decision-making tools that exist, as mentioned before (Taylor, 2015). It is most commonly used in the operations management area (Sarjono et al., 2020). The AHP allows for a score to be given to each alternative that is chosen, and it has the goal of ranking the several alternatives based on multiple criteria and then allowing for the person who is making the decision to select the best one out of the alternatives ranked (Taylor, 2015). According to

Asamoah, Annan, and Nyarko (2012), AHP has been acknowledged as a capable tool for evaluating and selecting suppliers. It also allows qualitative and quantitative data to be put for the criteria.

The steps for using the AHP tool are quite straightforward; however, several authors have their own steps and guidelines for implementing it. In order to make it as credible, simple and clear as possible to follow, a combination of the different papers (Russo and Camanho, 2015; (Sarjono et al., 2020; Tahriri et al., 2008; Taylor, 2015) approaches will be used in the following steps.

1. Define the problem and/or goal, as well as determine the information that is wanted:

It is important that the problem or goal is complex enough to be analysed and warrant the use of AHP.

2. Decide and define the criteria and sub-criteria if needed.

Here, the criteria connected to the goal or problem are decided on, defined, and noted down.

3. Design the hierarchical structure

The hierarchy to be designed is based on the AHP method and is built from the top with the goal of what the person/company wants to achieve at the top, then comes the criteria, followed by possible sub-criteria, and lastly, the alternatives. This structure can either be approached from a top-down or bottom-up process. However, it is important to make sure that there is a connection throughout the whole hierarchy and that everything is logically connected and only includes whatever is relevant.

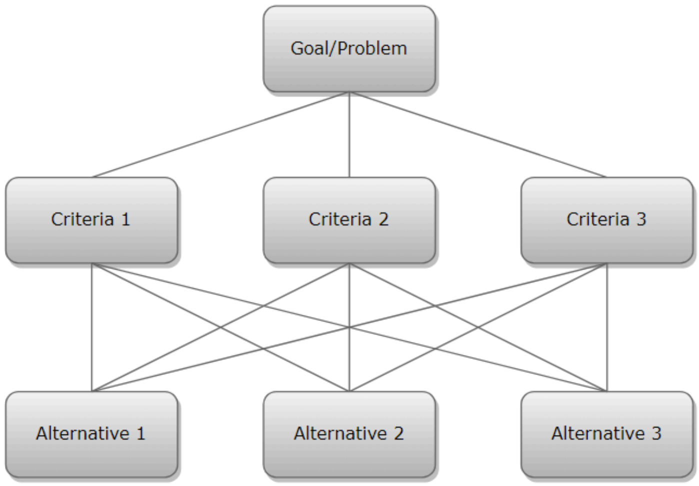

Figure 3.6: Hierarchical Structure of the AHP.

4. Construct matrices and do pairwise comparisons.

Two alternatives are compared to each other based on a criterion, and then the preferred one is decided. Afterwards, a pairwise comparison within the criteria themselves is done. These pairwise comparisons are made using a standardised scale that has been determined, and all the authors referenced above also use the same grading scale. The scale ranges from 1 to 9, as shown in Table 3.2.

Table 3.2: The measurements for the pairwise comparisons based on preference or judgment

Preference or Judgment	Numerical Value
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

In the constructed matrix, the advantageous alternative in that specific criteria has the numeric value X in the cell row, whereas the other alternative has the inverted value 1/X in its respective cell.

Table 3.3: Matrix of pairwise comparisons between the alternatives in regard to a criterion.

Criteria 1			
	Alternative 1	Alternative 2	Alternative 3
Alternative 1	x1	x2	x3
Alternative 2	y1	y2	y3
Alternative 3	z1	z2	z3

Table 3.4: Matrix of pairwise comparisons of the criteria.

Criterias	Criteria 1	Criteria 2	Criteria 3
Criteria 1	x1	x2	x3
Criteria 2	y1	y2	y3
Criteria 3	z1	z2	z3

5. Create and calculate the different weights of the alternative with regard to a criteria.

The goal of the matrix that has been constructed is to see which alternative is the most important regarding a specific criterion. First, sum each value in each column of the matrixes and then add a new row for the sums.

Table 3.5: Matrix of the added summation row with the values in fractions.

Criteria 1			
	Alternative 1	Alternative 2	Alternative 3
Alternative 1	x1	x2	x3
Alternative 2	y1	y2	y3
Alternative 3	z1	z2	z3
Sum	x1+y1+z1	x2+y2+z2	x3+y3+z3

Afterwards, divide each value by the sum of the corresponding column; this results in a normalised matrix.

Table 3.6: Normalised matrix with the values in fractions.

Criteria 1			
	Alternative 1	Alternative 2	Alternative 3
Alternative 1	x1/(x1+y1+z1)	x2/(x2+y2+z2)	x3/(x3+y3+z3)
Alternative 2	y1/(x1+y1+z1)	y2/(x2+y2+z2)	y3/(x3+y3+z3)
Alternative 3	z1/(x1+y1+z1)	z2/(x2+y2+z2)	z3/(x3+y3+z3)

Thereafter, sum the values in each row and take the average of that value for each row. This results in the preference of the alternative with regard to the specific criteria. The weight is given in the last column. Repeat this for all criteria.

Table 3.7: Normalised matrix with the average per row with the values in decimals.

Criteria 1				
	Alternative 1	Alternative 2	Alternative 3	Average per Row
Alternative 1	$x1_n$	$x2_n$	$x3_n$	$(x1_n+x2_n+x3_n)/3$
Alternative 2	$y1_n$	y2n	$y3_n$	$(y1_n+y2_n+y3_n)/3$
Alternative 3	$z1_n$	$z2_n$	$z3_n$	$(z1_n+z2_n+z3_n)/3$
Sum				Adding the above should sum to 1

6. Do the same step as 5 but for the criteria.

This results in the preference of the criteria compared against each other.

7. Create the ranking

Rank the alternatives by multiplying the weighted average value from each row given from the pairwise comparisons within the same criteria and then sum the values. For example, alternative 1 would be the following:

$$Alternative\ 1 = Weightforcriteria1 * Weightforalternative1withregardstocriteria1 + Weightforcriteria2 * Weightforalternative2withregardstocriteria2 + Weightforcriteria3 * Weightforalternative3withregardstocriteria3$$

8. Consistency check

Lastly, a consistency check must be done to ensure the weights are accurate. This is because the values given to perform the AHP can be inconsistent, for example, if this information is given verbally during an interview.

The consistency check is done by returning to the original pairwise comparisons, multiplying them with the previously calculated corresponding weight, and summing the result of each row. This is done for all pairwise comparisons.

Criterias	Criteria 1	Criteria 2	Criteria 3
Criteria 1	x1	x2	x3
Criteria 2	y1	y2	y3
Criteria 3	z1	z2	z3

*

Criteria Weights
Criteria 1 Weight
Criteria 2 Weight
Criteria 3 Weight

Figure 3.7: The matrix of Table 3.7 is multiplied by the previously calculated criteria weights by doing scalar product, row-column.

Afterwards, divide each sum with the corresponding weight for that criterion. Summing all values and dividing by the number of criteria will give the value called λ max. This is also done for the alternatives as well.

Next, to calculate the consistency index, the following formula is applied:

$$Consistency\ Index = \frac{\lambda max - n}{n - 1} : Where\ n\ is\ the\ number\ of\ elements \quad (1)$$

If the consistency index is not 0, then a consistency ratio needs to be calculated, which has the following formula:

$$Consistency\ Ratio = \frac{Consistency\ Index}{Random\ Index} \quad (2)$$

The random index was created by Thomas Saaty; a table of these values are presented in Table 3.8.

Table 3.8: Random index values for n.

n	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

When calculating this ratio, the result is acceptable if it is < 0.1 when controlling all the ratios of the criteria and alternatives. If the ratio is above 0.1, then the different results from the AHP should be analysed (Saaty, 1987).

3.3.1.2 TOPSIS

Besides AHP, the MCDM TOPSIS evaluates and selects suppliers. TOPSIS identifies the ideal solution from a finite set of points. The basic principle of TOPSIS is that the best alternative is based on short geometry. Thus, the best alternative has the shortest distance to the best alternative and the farthest distance to the worst alternative to find the ideal solution from the finite set of points (Gallego, 2011). An example of using TOPSIS would be choosing suppliers based on quality, delivery time, costs, and flexibility. However, these factors are quite difficult to decide upon, so TOPSIS is a method of assigning ranks to these factors based on the weight and impact of a given factor.

According to Hwang & Yoon (1981), the TOPSIS procedure requires certain steps, including descriptions and calculations, which can be described as follows. Initially, a set of alternatives (1) and a set of criteria (2), where X (3) indicates the performance ratings and w (4) is the set of weights, is created.

$$A = \{A_k | \, k = 1, \dots, n\} \quad (1)$$

$$C = \{C_j | \, j = 1, \dots, m\} \quad (2)$$

$$X = \{X_{kj} | \, k = 1, \dots, n; j = 1, \dots, m\} \quad (3)$$

$$w = \{w_j | \, j = 1, \dots, m\} \quad (4)$$

The first step of TOPSIS will be calculating normalised ratings by formula (5).

$$r_{kj}(x) = \frac{x_{kj}}{\sqrt{\sum_{k=1}^{n} x_{kj}^2}}, k = 1, \dots, n; j = 1, \dots, m \quad (5)$$

Formula (6) is applied to the benefit criteria, and formula (7) is applied to the cost criteria. The aim for the benefit criteria is to make it larger, while the aim for the cost criteria is to make it smaller. These formulas calculate the difference between maximum, minimum, and aspired level resp. max xkj, min xkj, xj*.

$$r_{kj}(x) = \frac{(x_{kj} - x_j^-)}{(x_j^* - x_j^-)} \quad (6)$$

$$r_{kj}(x) = \frac{(x_j^- - x_{kj})}{(x_j^- - x_j^*)} \quad (7)$$

Afterwards, the formula (8) calculates the weighted normalised ratings.

$$v_{kj}(x) = w_j r_{kj}(x), k = 1, \ldots, n; j = 1, \ldots, m \quad (8)$$

Once the weighted normalised ratings are known, the separation from the Positive Ideal Point and Negative Ideal Point between the alternatives is calculated. These separation values can be calculated using the Euclidean distance given by formulas (9) and (10).

$$D_k^* = \sqrt{\sum_{j=1}^{m} [v_{kj}(x) - v_j^+(x)]^2}, k = 1, \ldots, n \quad (9)$$

$$D_k^- = \sqrt{\sum_{j=1}^{m} [v_{kj}(x) - v_j^-(x)]^2}, k = 1, \ldots, n \quad (10)$$

Then, the similarities to the PIS can be obtained by using formula (11) where C_k^* an element between [0,1] is applied for all k =1,....,n. Finally, according to the similarities to PIS (C*k), the best alternatives can be chosen from (C*k) in descending order.

$$C_k^* = \frac{D_k^-}{(D_k^+ + D_k^-)}, k = 1, \ldots, n \quad (11)$$

As can be seen, there are certain benefits to TOPSIS, such as the concept of selecting alternatives by using TOPSIS for each criterion, because it can be described in a simple mathematical form. This leads to TOPSIS's logic being rational and having understandable computation processes. However, TOPSIS has certain drawbacks, such as rank reversal, which means that once an alternative is added or removed, it will lead to a total inverted order of preference (García-Cáscales & Lamata, 2012). Moreover, TOPSIS does not consider the relative importance of the shortest distance to the PIS and the greatest distance to the NIS, which could influence the importance of comparing criteria (Gallego, 2011).

3.3.1.3 The Hybrid Approach

As stated in Chapter 3.3.1, the MCDM AHP has been applied in several research studies due to its simplicity, consistency, and flexibility, which makes AHP the most used technique by itself or in integration with other techniques such as TOPSIS. Therefore, the hybrid MCDM AHP-TOPSIS will be researched to select and evaluate suppliers. This combination of

MCDMs is because AHP is used to evaluate selection criteria while TOPSIS is used to rank these acquired criteria.

Hanine et al. (2016) confirm that the AHP technique is well-known for structuring the problem, and TOPSIS is one of the most efficient ways to rank the alternatives to the problem. Jiménez-Delgado et al. (2020) and Haji et al. (2022) have been using the hybrid AHP-TOPSIS model as well, which has led both to great results. Comparing the proposed AHP-TOPSIS framework within the literature has led to a comprehensive understanding of the general AHP-TOPSIS model used to solve the MCDM problem.

The general AHP-TOPSIS model can be divided into three stages: identifying the criteria, weighting and computing, scoring, and finding a solution. These criteria are identified through unstructured interviews with experts and literature (Haji et al., 2022; Jiménez-Delgado et al., 2020). Thereafter, the weighting and computing are done by weighing the criteria using the method AHP. Within this method, a pairwise comparison matrix of criteria is constructed, which leads to the determination of the weights of the criteria. This step forms the construction of the hierarchy of the criteria by using AHP (Karim & Karmaker, 2016). The final stage, stage three, is scoring and solving using the TOPSIS method. The alternatives will be evaluated, and the PIS and NIS will be determined to calculate the final rank of the alternatives (Haji et al.m, 2022; Hanine et al., 2016; Jiménez-Delgado et al., 2020; Karim & Karmaker, 2016). Finally, the best alternative from the hybrid approach will be selected, and a conclusion will be drawn about which is the best.

In conclusion, the researchers state that further research can be conducted using the current model and other MCDM methods to ensure more comprehensive results. These researches included the hybrid approach as an alternative measuring technique to improve the evaluation of supplier systems (Zeydan et al., 2011). However, Hanine et al. (2016) stated that the proposed methodology seems imprecise in accurately capturing the judgement of the decision-makers, which can be seen as a serious limitation. According to Kumar et al. (2019), AHP requires data based on experience, knowledge, and opinion, which are subjective and thus biased toward each decision-maker. Moreover, AHP does not consider risks and uncertainties regarding the performance of the suppliers. Therefore, data collection has to be done carefully within this AHP-TOPSIS approach to ensure that the proposed model and results are not biased.

3.4 Warehouse Operations

The role of warehouses within the supply chain has become crucial because warehouses are constantly under pressure due to higher expectations of productivity and accuracy while reducing costs and improving customer service. This makes the warehouse not just a storage place but also a place to manage and operate value-added services. (Karim et al., 2020). The basic requirements within warehouse operations are to receive SKUs from suppliers, store these, receive orders from customers, retrieve SKUs and assemble the complete orders for shipping to the customers. However, many issues are involved in designing and operating a warehouse to meet these requirements where space, labour and equipment are to be allocated to function and operate successfully while minimising costs (Gu, Goetschalckx and McGinnis, 2007). Therefore, operations within a warehouse are complex environments that combine several processes and major operations, such as receiving, storing, and picking, where operational efficiency can be an important metric for successful operations (Halawa et al., 2020).

3.4.1 Receiving

The receiving of goods at a warehouse is among the least investigated topics within the warehousing literature, whereas warehousing has the highest operational cost for an organisation, representing 2-5 per cent of the company's selling costs. Therefore, receiving plays a significant role in warehouse operations (De Oliveira et al., 2022). According to Šaderová et al. (2021), receiving goods involves several steps describing the receiving process. These steps start with the vehicle unloading at the docks, where the documents and integrity of the delivered goods will be checked. Afterwards, the process includes quantitative and qualitative controls on the complexity of the goods so that these goods can be moved from the place of receipt to the place of destination, such as storage or cross-docking. Within these steps, certain decisions must be made when the goods are received at the warehouse to maintain an optimal internal material flow.

Gu, Goetschalckx and McGinnis (2007) state that decisions are based on information about incoming shipments, customer demands and warehouse dock layout, including available material handling resources. The amount of available information decides the assignment of carriers to the docks, the scheduled service of carriers at each dock and the allocation of material handling resources. However, these decisions are subject to performance criteria and constraints: resources required to complete receiving operations, levels of service, layout, management policies and throughput requirements for all docks. Rafaat & Showghi (2020) also state that receiving KPIs such as receipts per man-hour, % dock door utilisation, % receipt processed, and receipt processing time per receipt are significant to measure the performance of receiving goods at a warehouse. Moreover, the decision-making in receiving is limited by the amount of prior knowledge about incoming shipment where, in general, three situations can be described, which are no knowledge, partial knowledge of arriving processes and perfect knowledge of arriving processes (Gu, Goetschalckx and McGinnis, 2007).

These decision designs are especially for heterogeneous warehouses, whereas retail and e-commerce warehouses lead to special warehouse strategies. According to Tang et al. (2022), e-commerce warehouses face a different kind of order processing. E-commerce warehouses have small orders that contain small amounts of goods, and each order is offered from a large assortment that includes various SKUs. Moreover, e-commerce warehouses promise a tight delivery deadline as part of the service and have varying workloads during certain events such as Black Friday or Christmas. These aspects distinguish the order processing workflow of e-commerce from manufacturing warehouses. Whereas Gu, Goetschalckx and McGinnis (2007) and De Oliveira et al. (2022) state that research in receiving processes is still limited to this day, Tang et al. (2022) were able to identify the daily issues of the order processing data of e-commerce warehouses which were monitoring, analysing and evaluating. These daily issues are due to the rapidly incoming order volume, unclear delayed threshold, and puzzling decision-making on handling priority, which makes the receiving processes a very important part of the inbound logistics.

3.4.2 Storage

As mentioned before, storage is one of the major warehouse operations. The transfer and putaway processes to the storage locations of the received products are one of the explanations for the storage operation. The storage operation can contain tasks such as the physical movement of the goods from receiving to the storage area or repackaging the pallets and boxes they come into their own company-standardised bins (Pran and Aaseth, 2023). With this stated, there are three factors that determine the storage: how often the inventory should be replenished for an SKU, what the appropriate amount of inventory should be for each SKU, and where the SKU should be stored. Regarding the last factor, two of the major criteria for deciding on that are storage efficiency, which refers to the storing capacity available and access efficiency, which means the amount of resources used for both the storing and picking process (Gu, Goetschalckx and McGinnis, 2007). It is also necessary to choose the correct storage location for the SKU because it impacts the total cost when it is later retrieved. When a pallet is stored, the location should be recorded for several reasons; however, one of the reasons is for the operators that pick these to know where they are. It can also be used for a pick list when multiple SKUs must be picked simultaneously (Bartholdi and Hackman, 2019).

3.4.2.1 Storage Policies

Different storage policies can be used when allocating the SKUs. The three general policies that literature such as Derickx (2012), Farahani, Rezapour and Kardar (2011) and Sueters (2023) mention are random storage, dedicated storage and class-based storage. A random storage policy is when the SKU can be placed anywhere in the storage area, such as racks, as long as there is space. Dedicated storage is when the SKU is only allowed to be placed at specific locations, and the class-based storage policy is a mix of these two. The class-based storage policy is when the different SKUs are assigned to a class, and each class is assigned to a part of the storage area. Furthermore, the SKUs can only be placed within their dedicated assigned class. However, their stored location can be random within that area as long as there is available space. If the chosen policy is class-based, then there is usually a structured way to divide the SKUs into classes. Sueters (2023) states that an ABC or FSN analysis can be used to allocate the SKUs into different classes. Sueters (2023) also points out that the ideal classes are between two and five. Furthermore, De Koster, Le-Duc, and Roodbergen (2007) mention that one of the classic ways to divide the classes is to use Pareto's method with the idea that the most popular items that generate 80% of the turnover only use 20% of the storage space.

Moreover, there are two more storage policies to mention, one of which is the mixed shelves storage policy. This policy is used by many B2C retailers such as Amazon and Zalando. The logic is that the SKUs are taken from their packages or boxes and divided into single units, such as a single SKU, which are placed around the warehouse in different racks (Boysen, De Koster and Weidinger, 2019). Lastly, the final policy to be mentioned is the family grouping policy. The logic is to store the different SKUs often ordered together with those close to each other. This policy can also be combined with other policies, such as a class-based one (Chackelson et al., 2011; De Koster, Le-Duc and Roodbergen, 2007).

However, every storage policy has advantages and disadvantages, which means no policy is perfect for every scenario. Based on several pieces of literature, a table was constructed, shown in Table 3.9.

Table 3.9: Advantages and disadvantages of different storage policies.

Storage Policy	Advantages	Disadvantages
Random	• **High space utilisation** (Chackelson et al., 2011; De Koster, Le-Duc and Roodbergen, 2007; Derickx, 2012; Sueters, 2023) • **Simple to apply** (Derickx, 2012) • **Optimises the spreading of SKUs and reduces congestion**. (Derickx, 2012)	• **Increased travel distance** (Chackelson et al., 2011; De Koster, Le-Duc and Roodbergen, 2007; Derickx, 2012; Sueters, 2023) • **Needs computer controlled environment** (De Koster, Le-Duc and Roodbergen, 2007) • **Order pickers need to be well-informed about SKU locations** (Sueters, 2023)
Dedicated	• **Order pickers become familiar with the localisation of SKUs** (Chackelson et al., 2011; De Koster, Le-Duc and Roodbergen, 2007) • **Helpful if SKUs have big weight differences** (De Koster, Le-Duc and Roodbergen, 2007) • **Performs better than random if SKU forecast is highly accurate** (Sueters, 2023)	• **Low space utilisation**(Bartholdi and Hackman, 2019 ;Chackelson et al., 2011; De Koster, Le-Duc and Roodbergen, 2007; Sueters, 2023) • **Familiarisation becomes irrelevant if there are too many different SKUs** (Chackelson et al., 2011)
Class-Based	• **Reduced travel distance** (Chackelson et al., 2011) • **Flexibility** (Sueters, 2023) • **Simple to implement** (Sueters, 2023) • **Increased Familiarity within the zones** (Gu, Goetschalckx and McGinnis, 2007)	• **Medium space utilisation** (De Koster, Le-Duc and Roodbergen, 2007)
Mixed shelves	• **The average travel distance to an ordered SKU is reduced** (Boysen, De Koster and Weidinger, 2019; Weidinger, 2018) • **Easy adaption to the amount of workload needed** (Boysen, De Koster and Weidinger, 2019) • **Can handle large amounts of different SKUs** (Boysen, De Koster and Weidinger,	• **More effort during the put-away process** (Boysen, De Koster and Weidinger, 2019) • **Not good at handling high-order quantities** (Boysen, De Koster and Weidinger, 2019; Weidinger, 2018)

	2019)	
Family grouping	• **Higher order picking efficiency** (Derickx, 2012)	• **Less space utilisation than random** (De Koster, Le-Duc and Roodbergen, 2007; Derickx, 2012) • **Can lead to congestion** (Derickx, 2012)

3.4.2.2 Automated Storage and Retrieval Systems

Automated storage and retrieval systems (AS/RS) were introduced in the 1960s, and as of today, the AS/RS market offers a wide variety of options, all with different characteristics, such as speed and weight capacity (Turner, 2020). Due to their high flexibility and handling speed, these systems are often used in e-commerce warehouses (Azadeh, Roy and De Koster, 2019). Some AS/RS systems include unit load, miniload, shuttle system, and Autostore (Turner, 2020).

The unit load AS/RS system uses cranes going up and down the aisles. The SKUs that are placed on the cranes are placed on a pallet, which is then transferred through the aisle and put into either a single or double-deep rack system. Furthermore, these cranes are limited to one per aisle (Turner, 2020). The mini-load AS/RS system works very similarly to the unit-load system; however, instead of the cranes dealing with pallets, it handles smaller units such as cartons or totes (Torchio, 2023). Additionally, it can go up to four units deep, depending on the size of the cartons and totes (Edouard et al., 2022; Turner, 2020).

The shuttle system is different because it uses multiple robots to transport the storage containers. Instead of a crane, it consists of both the robots moving horizontally to reach further down the aisle and a lift to lift the robot to the desired vertical level. This results in the robot only moving in one dimension. However, multiple robots can pick and store at a time per aisle instead of only one, as in the previously mentioned systems. The number of robots per aisle depends on the lift; if it can lift the robot to three levels, the system has three robots; four levels mean four robots and so on (Moya, 2022). Lastly, the shuttle systems are single or double-deep in storage containers such as boxes (Edouard et al., 2022; Moya, 2022).

Autostore is different from the systems mentioned so far. The Autostore AS/RS system consists of robots, a metal grid, standardised bins, picking and putaway ports and a controller. The robots move on rails at the top of the grid and can pick, carry, and deliver the bins from the grid to the ports. If a bin is not at the top cell of the grid when a robot needs to pick it, then it uses a digging feature and moves the bin along the top until it reaches the desired bin. The grid is made of aluminium with rails built on top to allow the robots to travel. The grid has columns, and each has cells inside containing the bins. The standardised bins are boxes that can hold multiple SKUs. The bins also allow dividers within it for multiple compartments for smaller SKUs. Furthermore, the ports work as the delivery points for the robots holding bins. The bins are delivered to the ports, either picked up or filled with SKUs working as inbound or outbound processes. The controller works as the command centre for the Autostore, it contains information regarding bin locations, sends the tasks to the robots, manages route planning, etcetera (Autostore 2017; Edouard et al., 2022; Torchio, 2023). Lastly, both Torchio (2023) and Turner (2020) mention that Autostore is a great AS/RS system for e-commerce warehouses. Finally, the main characteristics differentiating these different AS/RS systems are presented in Table 3.10.

Table 3.10: Different AS/RS characteristics adopted from Edouard et al. 2022.

AS/RS	**Unit load system**	**Miniload**	**Shuttle**	**Autostore**
Speed	85 cycles/hour/carriage (60 for double deep racks)	120 to 200 cycles/hr/carriag e	500 cycles/hr/alley	1.6 m/s and 30 bins/hour/robot
Flow Rate	Low	Low	High (5 times higher than miniload)	Medium
Weight capacity	230-1815 kg	230kg max	90kg max	30kg max
Max Height	Very high(50m)	Very high	Medium	Medium(7m) between 4-16 bins
Ideal type of products	Heavy and bulky	Small and medium	Small and light	Small and light
Installation costs	High	High	High	Medium
Operating costs	Medium	Medium	Medium	Low
Space Utilization	Medium	Medium	Medium	High
System flexibility	Very low	Low	High	High
Ease of installation	Low	Low	Medium	High
Adaptability	Very Low	Low	Low	Medium

3.4.2.3 Inventory Categorisation Techniques

As mentioned, applying a class-based storage policy often involves a structured way to divide the SKUs. There are multiple inventory categorisation techniques, and they all have different criteria of what they weigh as a criterion for the categorisation. Three of these techniques are ABC, HML and FSN (Biswas et al., 2017).

The ABC system was originally derived from the Pareto principle (Biswas et al., 2017). It is a method that classifies inventory items into three classes: A, which is very important; B, which is moderately important; and C, which is the least important (Stevenson, 2014). These items are divided depending on either one or multiple criteria; however, the primary criterion usually used for this method is the annual dollar value for the items, which is calculated as the annual demand multiplied by the unit cost, this value is calculated for each item. Furthermore, the items assigned in the A class should be around 5-15 per cent of the total inventory, typically accounting for 70 to 80 per cent of the total annual dollar value. The B class consists of 30 per cent; however, it only has 15 per cent of the value. Lastly, C should contain 50-60 per cent of the inventory, however, it usually only holds 5 to 10% of the total value (Russell and Taylor, 2010).

The FSN technique, which stands for fast, slow, and non-moving, is similar to the ABC. In this system, the items are divided into three categories: fast, slow, and non-moving. When deciding which items go to which category, the turnover ratio must be calculated for each item, as shown in formula 1 (Devarajan and Jayamohan, 2016).

$$Turnover\ ratio = \frac{Annual\ demand}{Average\ Inventory} \quad (1)$$

According to Devarajan and Jayamohan (2016), the purpose of the FSN technique is to control the obsolescence of inventory items. Devarajan and Jayamohan (2016) also mention that for items to be put into the fast-moving category, the turnover ratio should be greater than 3. The slow-moving category requires a turnover ratio between 1 and 3; lastly, the non-moving items are for items with a turnover ratio of less than 1.

Furthermore, the HML technique is similar to the previously mentioned ones. However, it looks at the cost per unit instead and groups the items into either high, medium or low-cost categories (Biswas et al., 2017). Lastly, Biswas et al. (2017) mention that the purpose of the HML technique is to control the quantity of the purchase. Furthermore, high- and medium-value items require stricter quantities when purchased and stored in storage; low-value items can be more lenient.

These three methods generally categorise the items while only considering one criterion. According to Ravinder and Misra (2016), it is insufficient in today's competitive environment. Therefore, taking into account multiple criteria is something that has to be considered. However, Thakkar (2021) mentions that some multi-criteria techniques usually have disadvantages such as subjectivity, practical limitations and difficulty in understanding. Furthermore, Güvenir and Erel (1998) also mention that the downside of only measuring one criterion is that it does not consider other factors that may have an important meaning while classifying the SKUs. Lastly, Flores and Whybark (1986) mention a two-criteria matrix can be an approach to alleviate some of the disadvantages of only using one criterion, where one technique consists of the X axis and the other technique consists of the Y axis and thus achieve a more comprehensive control.

3.4.3 Picking

Besides receiving and storage, picking is a significant process that leads to a successful functioning warehouse if done efficiently. According to Shah and Khanzode (2017), 60% of all labour activities are accounted for by picking operations, which comprise as much as 65%

of all operating expenses in a warehouse. The picking operation is done by operators who must fulfil a picking list containing multiple individual orders from customers, followed by an order-picking strategy. These operators move to shelves and pick up the ordered goods to consolidate these in one package per customer. However, the variety of incoming online orders leads to an uncertain processing time for different picking lists (Tang et al., 2022). Therefore, Rafaat & Showghi (2020) identified KPIs to measure the picking process: picking costs per order line, order line picker per man-hour, percentage utilisation of picking labour and equipment, and order picking cycle time (per order). These KPIs are useful for designers of order-picking systems because Gue, Russel, and Skufca (2006) state that three main goals must be satisfied. These goals are throughput, space utilisation, and costs, meaning the number of pickers per hour, the amount of items stored in an amount of space, and the fixed and variable costs. Figure 3.8 outlines these picking operations. Within this chapter, the order picking methods and equipment will be discussed to obtain a deeper understanding of what the picking process is, in essence, and what it entails.

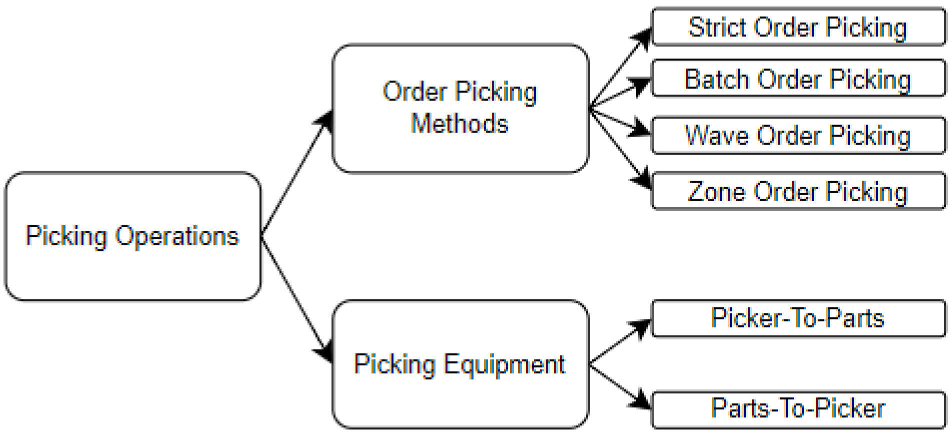

Figure 3.8: The picking activities adapted from Shah & Khanzode (2017).

3.4.3.1 Order Picking Methods

Every warehouse uses different order-picking methods to collect the goods and prepare them for shipment to the customer. These order-picking methods are based on the type of warehouse operations, and the most cost-effective way is to collect the goods. Several types of research have delved deep into different kinds of picking policies that exist within warehouse operations (De Koster, Le-Duc and Roodbergen, 2007; Gu, Goetschalckx and McGinnis, 2007; Gue, Meller and Skufca, 2006). Shah and Khanzode (2017) identified three basic picking policies within warehouse operations: zone, wave, and batch picking. Shetty, Sah, and Chung (2020) confirmed these types of picking policies but added one, namely strict order picking. Therefore, within the literature, four basic types of order-picking methods have been identified: zone, wave, batch and strict order picking.

Strict order picking requires a picker to cover the complete route in a warehouse and gather all the required materials to complete a single customer order (Shetty, Sah and Chung, 2020). According to Eisenstein (2008), strict order picking is quite common due to its simplicity, reliability, and ability to pick orders quickly upon receipt, commonly used by e-commerce operations. Moreover, this method lacks mispicks but is labour-intensive to maintain and has lower productivity due to more worker travel per item picked (Gue, Meller and Skufca, 2006). Therefore, strict order picking has its disadvantages, but there are two primary ways to reduce the costs of this method. Firstly, Eisenstein (2008) states that through the use of technology such as conveyor systems, the use of mobile units can reduce costs. Secondly, the warehouse design contains the best locations where workers receive pick lists, deposit completed orders, and the best way to lay out the products.

While strict order picking involves the completion of a single order, batch picking involves multiple orders consolidated in a picking round. The picker only returns to the depot and starts the next round when the batch of orders is completely assembled. This increases the pick density per round, resulting in a more efficient picking process than strict order picking (Boysen, De Koster and Weidinger, 2019). Batching contains two criteria: the proximity of pick locations and time windows. Proximity batching allocates each order to a batch based on the proximity of its storage locations. The major issue is the measurement of proximity among orders, which sets a sequence for visiting a combination of locations in the warehouse. Under a time window, batching is defined as orders arriving at certain time intervals and being grouped as a batch. During the process, orders can be sorted and split if possible, leading to higher picking accuracy (De Koster, Le-Duc and Roodbergen, 2007).

According to Khanzode and Shah (2017), batch picking only applies to small orders because one order per round is not economical. Moreover, the batching process becomes more costly and time-consuming when the number of customer orders increases, but it can be overcome by a joint approach of batching and picking, which involves sorting out order-wise products. Therefore, batching shows different tradeoffs between performance issues, such as picker vs. speed, order completion vs. lead time, and efficiency vs. response time, which must be considered. Gu, Goetschalckx and McGinnis (2007) also state that batching performance is difficult to evaluate because the performance depends heavily on factors such as storage location assignment policies, routing policies, structure of orders, storage systems, and the maximum batch size.

Another order-picking method, wave picking, means that a certain number of batches, a wave, is picked simultaneously by order pickers. So, all order pickers pick one batch and start simultaneously (Gademann, Van Den Berg and Van Der Hoff, 2001). Wave picking is used if orders have to be sent to a common destination such as Helsingborg, Stockholm, etc. The batch size is determined by the required time to pick a complete batch, and the following wave can only start when the previous one is completely picked (Koster, Le-Duc and Roodbergen, 2007). However, the completion of one wave is determined by the outgoing vehicle schedule or the requested time by the customer, where the wave order picking period tries to avoid storage, staging, and restocking of the warehouse in order to achieve higher efficiency (Khanzode and Shah, 2017).

Lastly, zone picking is an order picking method where the warehouse is divided into multiple areas, including assigned pickers to each area to reduce travel time and distance for picking the goods (Shetty, Sah and Chung, 2020). The definition of zoning is a logical storage area that could include a pallet storage or an entire warehouse split into multiple areas where these areas can be determined by product size, weight, temperature, and safety requirements (Khanzode and Shah, 2017). According to Gue, Meller and Skufca (2003), zone picking maintains high productivity if the workers do not stand idle. Moreover, Gu, Goetschalckx and McGinnis (2007) state there are more advantages to zone picking, such as limited distance to pick an order, increased familiarity of the picker, and reduced picking time span for an order. but could be costly due to downstream sortation. However, it could be costly due to downstream sortation, such as sorting in parallel zone picking and queuing in sequential zone picking (Gue, Meller and Skufca, 2003; Gu, Goetschalckx and McGinnis, 2007).

3.4.3.2 Picking Equipment

The picking of goods requires, most of the time, some form of equipment instead of being done by the operators of the warehouse. According to Gong and De Koster (2011), picking equipment can be divided into picker-to-parts and parts-to-picker equipment. Firstly, in a picker-to-parts system, pickers will walk or drive through the warehouse and pick up the designated items. Two types of levels can be distinguished: low-level picking and high-level picking. In the low-level order-picking system, the picker travels along the aisles to collect the goods from storage racks or bins where pick inaccuracies can occur, leading to uncertainty in the picking process. In high-level picking, the picker travels along the aisles in the warehouse by forklift or crane in order to collect the goods from the appropriate location, which is located at a high level where congestion could occur.

Secondly, a parts-to-picker system includes several systems, namely automated storage and retrieval systems (AS/RS) such as miniload, Vertical lift module, and horizontal and vertical carousel (Koster, Le-Duc and Roodbergen, 2007). These AS/RS are storage systems that provide access to all sorted items using a stacker crane equipped with a vertical and horizontal drive and are widely utilised in the logistics industry. This has led to major advantages, including high throughput, efficient use of space, high reliability, and improved safety. However, the disadvantages are that AS/RS requires high initial investment, operational policies, inflexible layout and fixed storage capacity (Hu et al., 2005).

Ultimately, the pickers' system depends on the kind of operations within the warehouse. Therefore, Boysen, Koster and Weidinger (2019) created an overview of which warehousing systems are suited for e-commerce. These systems were based on what online retailing has to assemble (I) small orders from (II) a large assortment under (III) great time pressure and have to flexibly adjust order fulfilment processes to (IV) varying workloads, as shown in Table 3.11. The importance of the 4 given factors varies with offered products and type of business strategy for each company, which means that this table is not generally directly applicable.

Table 3.11: Suited warehousing systems for e-commerce adapted from Boysen, Koster and Weidinger (2019).

		(I) Small orders	(II) Large assortment	(III) tight schedules	(IV) Varying workloads
Low	Traditional order-by-order picker-to-parts warehouses		X		X
	Mixed-shelves storage	X	X	X	X
	Batching, zoning & sorting	X	X	X	
Level of automation	Dynamic order picking	X		X	X
	AGV-assisted picking	X	X	X	X
	Shelf-moving robots	X	X	X	X
	Advanced picking workstation	X	X	X	
	Compact storage systems		X		X
High	A-frame system	X		X	

4. Empirical Study

The empirical study includes all the company data that has been gathered and measured. This chapter includes the company description and the functionalities of the departments that communicate together. Thereafter, the warehouse design and operations are described which include each operation within the warehouse regarding receiving, put-away, picking and shipping. Moreover, the times of different processes within these operations have been manually measured. Lastly, the information regarding supplier relationships is gathered through interviews and observations.

4.1 Company Description

Boozt works with different departments that communicate with each other about the process of ordering goods from the suppliers and making decisions. In return, the departments report to the Chief Product Officer (CPO) about the current state of the processes, as shown in Figure 4.1. The Buying & Merchandise department works as one unit where partnerships are negotiated with the involved suppliers and stakeholders. Each employee in Buying and Merchandise and Supply Chain Management has responsibility over a certain number of brands depending on the position within the company. For example, one employee oversees 30 brands, the relations are constantly maintained, and deals are closed for future deliveries to the warehouse. The buying process is done by this department, and its responsibility lies in strategically deciding to allocate the money to suppliers, which is based on data. Decisions made by Buying and Merchandise have to be directly communicated throughout the chain because miscommunication could affect the quality of the processes.

The Buying and Merchandise department communicates closely with the Supply Chain Management department in order to assure and set strategies for the whole supply chain and its processes. The bigger part of the supply chain management tasks are still manual and are set to be more automatic by optimising the processes as much as possible. The Supply Chain Management department mainly communicates as a bridge between Warehouse Operations and Buying and Merchandise. The Warehouse Operations department has the task of making the warehouse as efficient as possible and will be significantly affected by choices such as contracting new suppliers or changes in order quantities from the other departments. Therefore, these three departments and the CPO try to obtain an effortless operation by communicating in an efficient and transparent way.

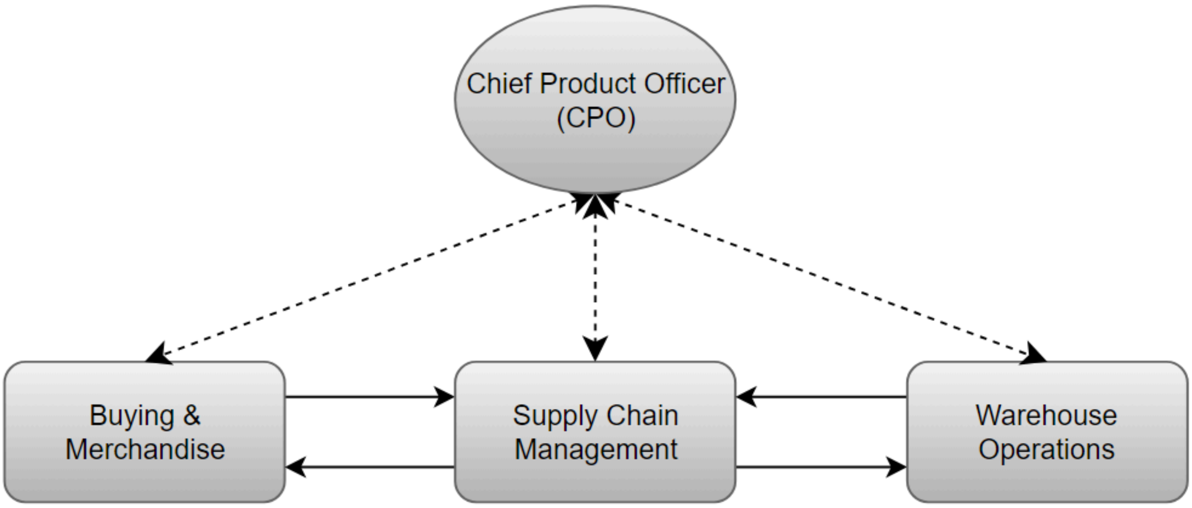

Figure 4.1: Communication between the departments.

As discussed in interviews and sources, the company sells many items such as shoes, jeans, t-shirts, underwear, etc. However, these clothes can be put into several categories: shoes, fashion, multipack, outwear, sports, toys, home, bags, and beauty. These categories can depend on seasonal changes and special days such as Christmas or Black Friday. Therefore, the company has to closely inspect the expected demand and supply for all these categories. The departments will decide which categories and contents are popular now or will be in the future. When these items are chosen, supply chain management and warehouse operations have to manage the supply and demand of these items to maintain an efficient process flow when new items from categories are being delivered at the warehouse and processed for shipping.

4.2 Warehouse Design and Operations

The company rents a warehouse at a location that includes three buildings with specific functions, as shown in Figure 4.2. The area has a main entrance and exit for incoming and outgoing goods. The goods are to be sent to the inbound area, and this area connects the two main buildings, A and B, which have Autostores 1, 2, and 3. Building A contains Autostore 1 and 2, the sorting & Value Added Services (VAS) area, and the outbound area for outgoing goods. Therefore, building A is the place where the most popular and preferred goods are stored to be quickly sent away to the outbound area. On the side of the Autostores, marked red, the put-away area can be found where the incoming goods will be processed into the Autostores. Underneath the Autostores, which are purple marked, the picking area can be seen, where operators pick the goods from the Autostores, put them on the conveyor belt, and send them to the green area, which is the sorting area. The small green area in building C is a sorting machine as well but a simple one, where these goods are sent manually to the bigger sorting area in building B. Lastly, the main building contains several refill areas, blue marked, where these are used to refill the Autostores when required. Moreover, building A contains a big refill area where hanger items and goods for refill for the Autostores are located.

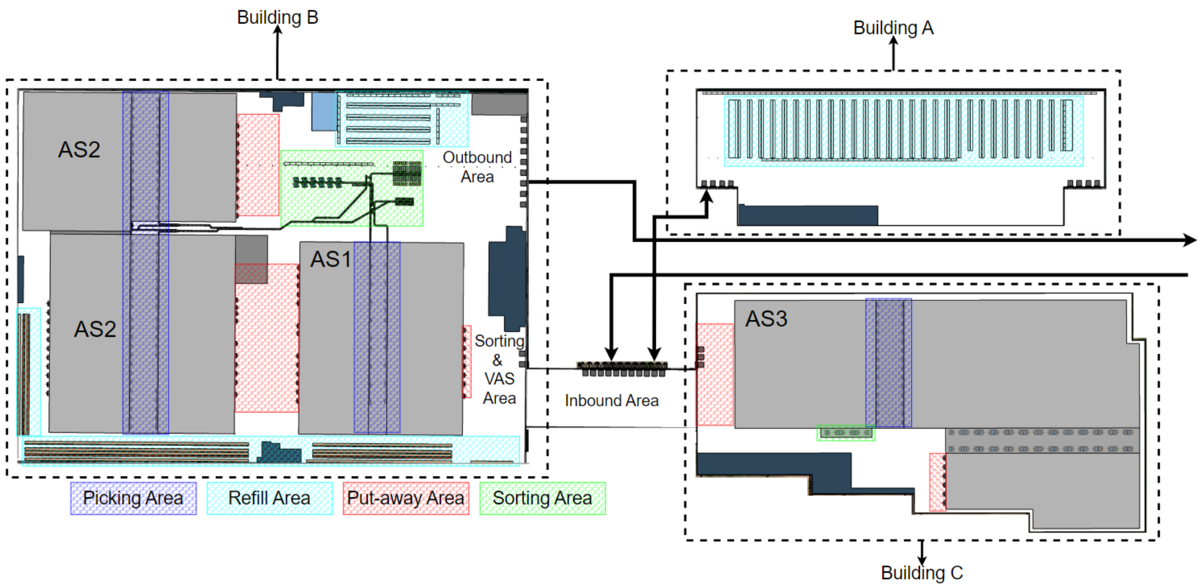

Figure 4.2: The current layout of the warehouse.

Based on the company data, a swimlane map has been created to describe the ongoing processes in the warehouse. The map is divided into five segments: suppliers, receiving, put-away, picking, and shipping. These five segments describe the main parts that occur within the warehouse, which will be described in the following chapters. The swimlane map will be shown, creating an overview of the processes in the warehouse.

4.2.1 Receiving

The process starts with the suppliers receiving an order from the warehouse, where this order will be processed and sent to Boozt's warehouse. The trucks come in based on the time delivery tool the supplier agreed to book from the contract they signed; otherwise, the trucks come in randomly to the inbound area of the company if nothing has been agreed upon. The second segment is the receiving part, where the pallets are unloaded and put in the inbound area. These goods will be scanned, and the operator will decide where to put them. If the pallet contains a mixed European Article Number (EAN), large quantities or anything out of the ordinary, then the pallet will be sent to the sorting location where sorting is required.

This sorting logic, which takes place while receiving the goods, is done by assessing the amount of a category of goods, such as shoes, fashion, or multipack, as shown in Figure 4.3 or Appendix B, Sorting logic. For example, the shoes can be divided into kids, regular and oversized, depending on the quantity where they should be stored. The kids' shoe shipment will contain 200 shoes, where 150 will go to the Autostore, and the other 50 kids' shoes will go to the refill. The regular shoes will be stored in refill if the quantity exceeds 60; if it's lower, it will be stored in one of the Autostores. The oversized shoes do not fit in the autostores; therefore, they will not be stored in refill because they do not fit in the bins. For this reason, the oversized shoes will be stored in the AGH location, a specific location in the warehouse that is only for oversized shoes.

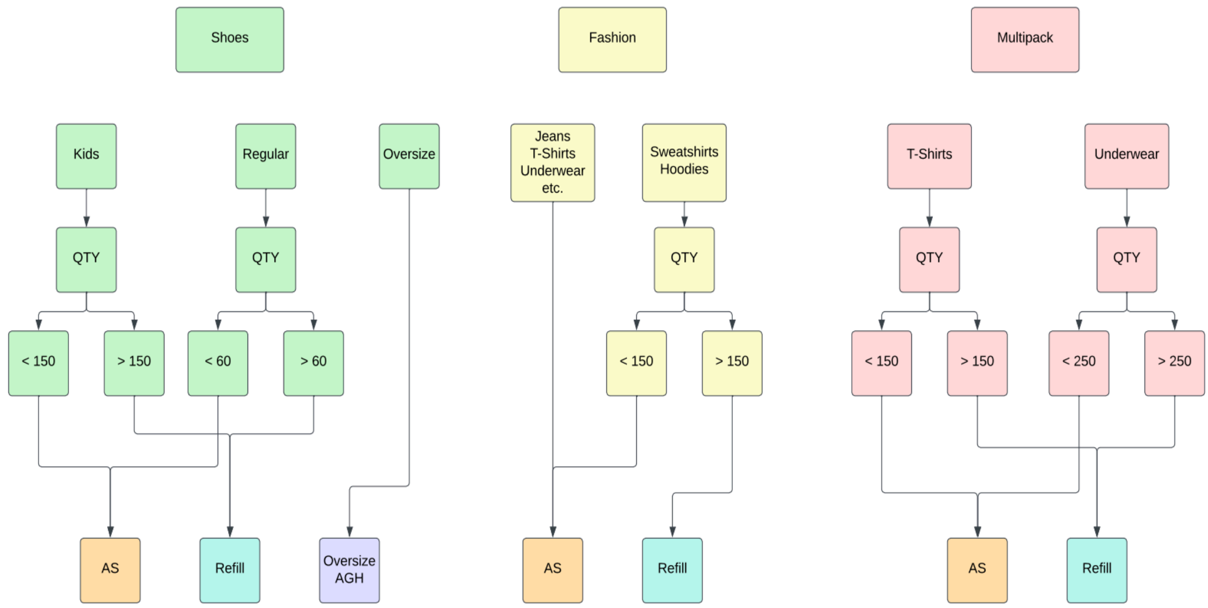

Figure 4.3: Part of the sorting logic of the company.

At the sorting location, which is a different activity from the sorting logic, the operators sort EAN/Boxes to ensure one EAN on each location. When the sorting is done, a pallet can be sent to either AS1, AS2, AS3, refill or the Helsingborg warehouse, depending on the quantity and type of product, as shown in Figure 4.3. However, if the products are not properly sorted within the deals or contracts, the VAS will correct the orders, and consequently, the supplier will receive an invoice. The VAS can occur in both flows, during unloading and put-away in the Autostore.

4.2.2 Putaway

If the pallet requires VAS, then the goods that have been serviced are then put into AS1 directly from the VAS area in most cases, however, sometimes the goods get transported away from the VAS to be put in AS2. If the pallet does not require sorting or VAS, then the pallet will be sent directly to either AS1, AS2, AS3, refill or the hangers based on the sorting logic explained and presented before. It should be noted that from both the observations at the warehouse and when asking the Logistic Project Manager, some pallets almost always need to be processed at the sorting or VAS.

When the pallet is sent to AS1, AS2 or AS3, the operators working there work at an Autostore putaway port. The operators receive the pallets with goods, unpack them, and put them in the bins. Each bin has compartments consisting of either 16, 8, 4, 2 or 1 slot, and these are used to separate the SKUs, allowing multiple SKUs to be placed in one bin. Additionally, the system tells the operator which compartment to put each SKU in. Afterwards, once a bin has been filled up at the putaway Autostore port, it is taken away by the Autostore system and is officially in the Autostore storage grid, and the operators receive a new bin to fill.

Figure 4.4: Pictures of one Autostore storage grid at the company's warehouse (self-taken).

Boozt's Autostore consists of two types of Autostore robots: the red line and the black line robots. The red line is the standard one and consists of the majority of robots that Boozt uses, the main difference between the two types is that the black line robots can switch out their battery; meanwhile, for the red one, this has to be done manually. Another difference is that it is slightly quicker and takes less space than the red one. Furthermore, each cell can be filled with up to 16 bins. However, Boozt aims to have an 80-90% fill rate of the Autostore because anything above this lowers the overall efficiency. Lastly, if one of the robots has issues or shows preemptive signs, they have a maintenance team at the warehouse to take care of the problems.

The goods put in the hangers are taken to building A by an operator and manually put into classic hangers used for clothes. Moreover, when the goods are being sent to a refill area, the goods will be put into classical pallet racks with the use of a forklift. However, if one Autostores requires a refill, the operator picks the pallet from the racks and takes it to one of the Autostores putaway areas. Otherwise, when there is no need to refill the Autostore, the goods remain idle at the stored location.

Currently, the refill storage locations for the pallets are being done by mixed decision-making between the operator deciding first that the EAN is to be put in refill and Boozt's software system. When the goods have been decided to be refilled by the operator, the software shows where there are free locations based on zones around the warehouse. The operator then chooses a zone with the best location for the EAN based on their own personal experience working at Boozt, and then lastly, the system assigns a random location within that zone. Thereafter, another operator comes with a forklift, picks it up and stores it. Finally, according to an ABC analysis, the zones are not differently prioritised, which makes these zones where Boozt has their racks and are not following any certain priorities.

4.2.3 Picking

Once an order has been placed, the picking phase starts with the Autostore robot collecting and delivering the bin to the Autostore picking port. Once the bin arrives at the port, one of the operators picks up the specific SKU ordered. The operator knows which SKU to pick based on a screen at each port highlighting the correct compartment for the operator to pick from. Once the whole order has been picked and packed, the operator places it on a conveyor belt, leading to the sorting machine that allocates the goods in different storage cages in the outbound area. However, the orders picked in Autostore 3 do not have the sorting process and are put in a storage cage at Autostore 3 instead, containing the finished goods. Afterwards, these finished goods will be brought manually to the outbound area together with all the other finished goods that arrive from Autostore 1 and 2. As mentioned, special products like suits and wedding dresses are placed in the hanger area, requiring a person to manually pick them up at that location.

Lastly, if an order has SKUs in different Autostores, these must be consolidated before the picking process can proceed. This means if there are three different SKUs being ordered, two of them in Autostore 2 and one in Autostore 1, the SKU in Autostore 1 has to be manually brought to Autostore 2 to consolidate the order. However, it should be mentioned that Boozt is currently building a solution that will allow this consolidation process to be automated instead of manual.

4.2.4 Shipping

The final step in the process before the customer receives it is shipping. This is a short process because it is handled mostly by 3PLs. Once the finished goods arrive in the outbound area, they are allocated to the different cages, as mentioned. These allocations depend on factors such as the designated country the finished products are going to or the type of 3PL. Furthermore, there is also a manual final sorting process for certain orders due to special aspects such as orders going to, for example, Iceland. The 3PLs that collect the goods are booked by Boozt, and the 3PLs have their assigned time slot for when they come and pick up the goods. The goods are then picked up by the 3PLs and delivered to the customers.

Finally, a swimlane map was created based on the processes described in Figure 4.5. The swimlane map has five lanes: suppliers, receiving, put-away, picking and shipping. In the suppliers' lane, the suppliers receive an order from the warehouse, which will be processed and sent to Boozt’s warehouse. After delivery, the receiving lane receives the goods where these are scanned. However, if the goods require sorting, then the goods will be sorted at the sorting location that can contain a VAS. The goods will be sent to one of the Autostores or refilled at the end of the receipt. Then, operations will store these goods at the designated locations. In the picking lane, the orders will be received from the customers and picked from the Autostores. Afterward, these goods will be put on a conveyor belt, and then the orders will be sorted for each destination. Finally, the goods will be put on pallets and loaded on the trucks in order to be shipped to the customer.

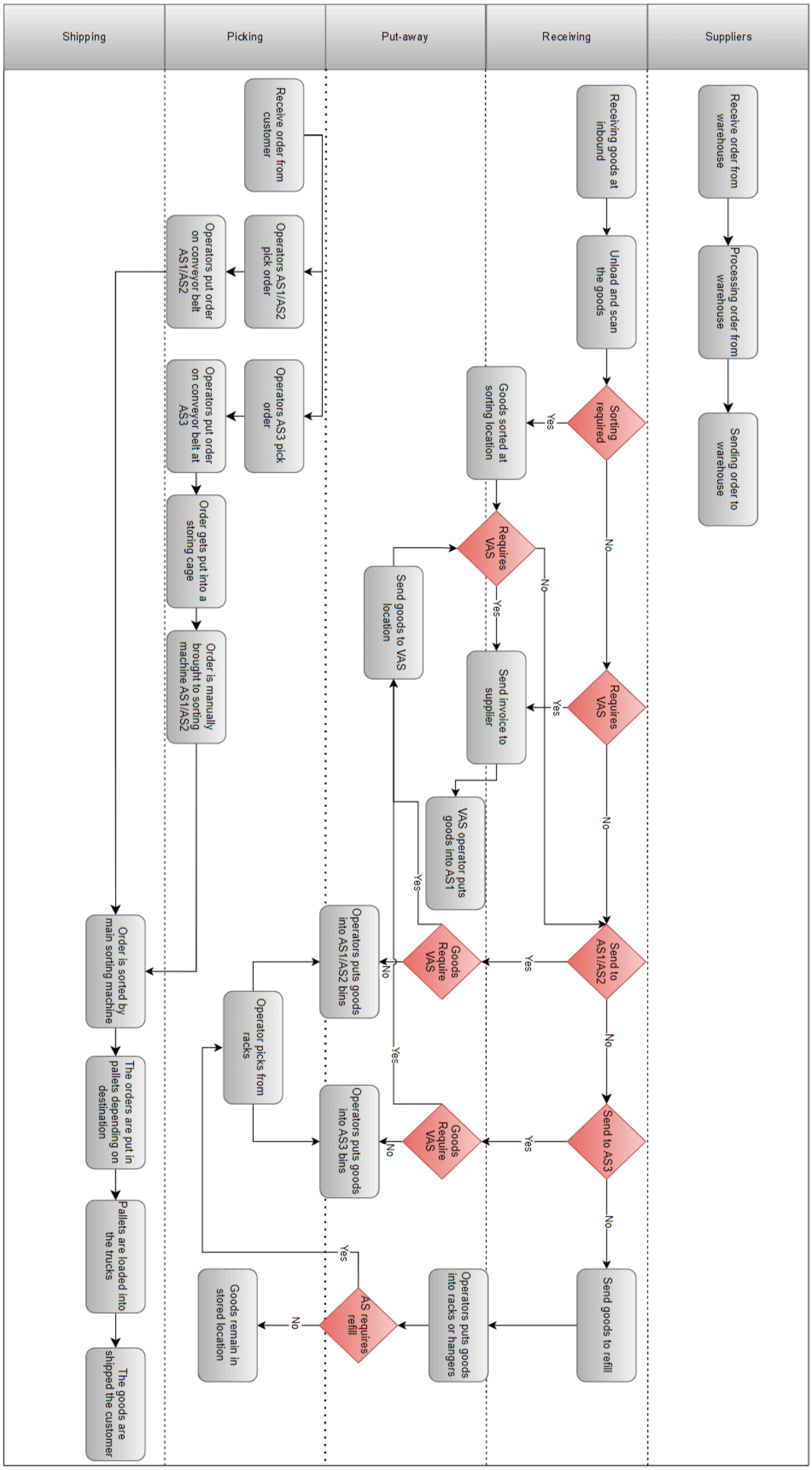

Figure 4.5: As-Is Swimlane diagram of the warehouse processes constructed by the authors.

4.3 Data Measurement of Inbound Processes

Several data points, such as cycle times and the time of Boozt's inbound processes, had to be collected for the research. This was conducted through interview questions and the third warehouse operations observation, which lasted for five hours. During this observation, the cycle times (C/Ts) of the different processes were measured with stopwatches. The processes consisted of forklifts unloading pallets from the delivery trucks arriving, scanning and labelling the pallets, put-away and picking. Each process was measured a certain amount of time until the cycle times started to be consistent. The VAS and sorting processes data were given by the VAS operators through Boozt's FastLane system. The times regarding waiting time between the processes were given by one of the head operators and not measured. The times of the processes are shown in Table 4.1.

Table 4.1: Times of different processes at Boozt's Warehouse.

Processes	**Average Time**
Unloading one pallet from the delivery trucks	70.13s C/T
Scanning and labelling process for one pallet	25.2s C/T
VAS time per SKU	173.4 seconds C/T
Sorting time per SKU	398 seconds C/T
Put-away time for each bin	62.42 seconds C/T
Picking time for each order	109.29 seconds C/T
Time pallet standing idle at inbound area	0.5 Hours
Time for pallets that are up to standard standing idle after receiving until putaway	71.5 Hours
Average time pallets standing idle at VAS/Sorting	13.64 Hours

4.4 Supplier Relationships

Currently, the supplier's relationship with the company is more transactional. They have as an objective to be long-term with them however, as of now, they are mostly short and mid-term relationships, one of the reasons for this is to allow the company to be more flexible and allow them to look for new opportunities if wanted. There are currently no major-specific incentives for the suppliers in case they do exceptionally well other than more orders being placed, which depends on customer demand. However, one minor thing is Boozt's yearly award winner competition in each category, where suppliers can win awards from Boozt.

Boozt is among the biggest customers for their suppliers, for most Nordic brands, they are the biggest however, for some, they are not. If the supplier has a Nordic department, then Boozt is usually the Nordic department's biggest customer. Additionally, the fact that Boozt is centralised in the Nordics makes it easier for them to be closer to their partners. With this said, Boozt is prioritised by the suppliers, and the few times they are not, there is a common understanding from both parties since there is a requirement for a partnership from both sides in order to achieve a win-win situation. Sometimes, this partnership requires the supplier to adapt to Boozt in order to meet some criteria, and other times, Boozt has to be the one to adapt, for example, one brand does not supply pallets with their goods, however, this is handled through negotiations and solved. Furthermore, it should be mentioned that as there are exceptions like the above being made for the sake of partnership, most of Boozt's partners use the delivery duty paid incoterm in the contract for deliveries, this puts the responsibility and transportation costs on the supplier until the goods arrive and have been delivered to Boozt. Lastly, Boozt does not utilise KPIs much for their suppliers' performance in the supply chain management and warehouse operations departments. One of the few KPIs being used is the amount of invoices sent to the supplier. Instead, Boozt looks at aspects such as whether the supplier has set up everything in Boozt's systems and is utilising the booking tool.

Communication with the suppliers is done with systems such as their business intelligence (BI) system and bi-weekly meetings with their suppliers. However, most suppliers do not interact much with the company's other departments other than the buyer and merchandise department. Furthermore, they usually only know the one specific buyer responsible for the supplier and establish contact with them. Lastly, there is no prioritisation between the suppliers other than the quantity of orders indirectly controlled by customer demand.

Lastly, to conduct the AHP, information on the criteria that Boozt found important was needed. Through interviews with the supply chain management and warehouse operations departments, product data, responsibility, and delivery reliability were identified as important criteria. Furthermore, the six top value-adding vendors for Boozt were given; however, they will be shown as vendors 1, 2, 3, 4, 5, and 6 for confidentiality purposes.

5. Analysis and Results

This chapter highlights the analysis and the data results regarding observations, measurements and literature. At first, the warehouse is discussed, and its operations regarding refill are based on the mapping that has been done. Afterwards, the characteristics of the maps are analysed and discussed whether there is opportunity for improvement or change in the processes of the inbound logistics. Then, the suppliers are evaluated, analysed and discussed using the hybrid AHP-TOPSIS approach. Lastly, the results of the AHP-TOPSIS approach are used to identify what kind of relationships Boozt has with its suppliers and how these relationships should be approached and improved based on the results.

5.1 Warehouse Refill Storage System

As previously discussed in Chapter 3, two major criteria decide where SKUs should be stored: storage capacity and the resources used for both putaway and picking processes (Gu, Goetschalckx, and McGinnis, 2007). Furthermore, Bartholdi and Hackman (2019) mentioned that if the storage locations are correctly chosen, they will reduce the total cost. Therefore, deciding where to place the refills plays an important role in warehouse operations, considering this is a daily process for Boozt.

Placing Boozt's current refill storage system into the different storage policies that have been brought up in the literature is not directly applicable. This is due to the pallet placement not being entirely random. As mentioned, it first gets placed in a zone, which is decided by the operator and then the placement in that zone is entirely random. For that reason, Boozt could identify these zones as a class-based storage policy. However, according to Derickx (2012), Farahani, Rezapour and Kardar (2011) and Sueters (2023), there is a structured way these storage classes need to be divided in order to qualify as a class-based storage policy. For Boozt, this is not the case because the classes are simply located around the warehouse and manually chosen by the operator. With this in mind, Boozt's current storage policy is mainly random, with a touch of decision-making based on the operator's experience.

To further argue for the reasoning that Boozt's policy is random, there is one aspect that has to be brought up. The fact that the operators should determine if a pallet contains certain SKUs which are popular or not in the market is beyond their job requirements as they are regular floor workers. Additionally, since Boozt is in the e-commerce market where there is constant change in demand depending on aspects such as seasonality or popularity, as well as how fast the supply chain and the amount of different SKUs Boozt has at a given time, it is unreasonable to expect that each operator knows which SKUs are popular based on working experience. Therefore the specific refill area that is being chosen by the operator could be said to be mostly random decision making. With this being stated, Boozt's current storage policy is, in fact, not a class-based policy but a random one and will be treated as such when analysing this.

According to the literature review, the advantages of a random storage policy are high space utilisation, simpleness, and the spreading of SKUs to reduce congestion. However, considering that the racks that utilise the current storage policy at Boozt are not the main part of Boozt's storage, space utilisation may not be considered a crucial aspect. Looking at the layout in Figure 4.2, it is clear that the Autostores occupy most of the warehouse space. However, the Autostore has its own storage system, which is not being examined. Moreover, the disadvantages of the random storage policy are increased travel time, a computer-controlled environment, and order pickers must be well-informed about the SKU locations. The main issue with the increased travel distance in Boozt's situation is that it can become a bigger issue than just the distance. For example, if an operator decides to allocate the pallets to be placed in building A, refill racks require an operator to pick it up and place it in Boozt's internally hired truck to move it across the buildings. Thereafter, pick it out from the truck and put it on one of the racks in building A. When these pallets have to be picked up and put into the Autostores, the same process will be used to get them back across the buildings to the Autostores. Therefore, with the random storage policy, there is a chance that a popular SKU gets placed in building A. As a result, SKUs must be collected more frequently, leading to more handling, movement, time consumption, and manpower.

In conclusion, from other storage policies and their advantages and disadvantages, the class-based storage policy seems to stand out as the most appropriate due to several advantages and disadvantages. For example, the dedicated storage policy would not be a good match, considering the shift in the SKUs in the e-commerce industry due to seasonality and market demand. Therefore, the advantages, such as the familiarisation it provides, are not present. Also, the benefit regarding weight difference is irrelevant, considering all Boozt's SKUs are similar in weight. Moreover, the mixed shelves policy is simply not applicable in this situation because Boozt's whole system is currently working differently from the mixed shelves policy.

As mentioned, the Autostore takes up the majority of the space in the warehouse. Therefore, it is crucial that this system has a high space utilisation. Edouard et al. (2022) presented from Table 3.10 that it can be seen that Autostore has the highest space utilisation compared to the other three presented AS/RS systems. Additionally, the ideal type of products used in this system are small and light, which are the main SKUs that Boozt sells. Furthermore, Torchio (2023) and Turner (2020) mention that Autostore is a great AS/RS system for e-commerce warehouses due to its benefits. With this considered, and Boozt is currently built on the Autostore system, there will not be much input.

In the literature review, Sueters (2023) states that an ABC or FSN analysis can be used to divide the classes for the class-based policy. With this in mind, there are more techniques than ABC and FSN. However, their purposes are different. Biswas et al. (2017) add these techniques with the HML technique, which could also be an interesting categorisation.

Comparing these three techniques regarding Boozt's market, the HML technique does not seem attractive in this case due to the shortage of very high-value items present where the quantity has to be strictly controlled. This means the FSN and the ABC inventory categorisation techniques are more desirable. Lastly, in line with the suggestion of Flores and Whybark (1986), to apply a two-criteria matrix to reduce the disadvantages of only having one criterion, then a matrix such as Table 5.1 can be done to divide the SKUs into classes.

Table 5.1: Two-criteria matrix based on ABC and FSN inventory categorisation.

ABC/FSN Matrix			
	F	S	N
A	AF	AS	AN
B	BF	BS	BN
C	CF	CS	CN

AF = Fast moving items in Group A
BF = Fast moving items in Group B
CF = Fast moving items in Group C
AS = Slow moving items in Group A
BS = Slow moving items in Group B
CS = Slow moving items in Group C
AN = Non-moving items in Group A
BN = Non-moving items in Group B
CN = Non-moving items in Group C

With the arguments done previously regarding the different storage policies, it is recommended that Boozt implement a class-based storage policy in order to have the highest benefits when deciding on the refill structure. The classification does not necessarily have to be an ABC-FSN matrix, however, both these categorisations can be valid for an e-commerce company. For example, tracking the goods based on turnover ratio, classifying the goods and comparing the goods' value can be desirable traits for an e-commerce company. Even though the e-commerce world is fast-paced with generally fast-moving items, there may still be slow or non-moving items due to the broad category of products Boozt provides.

Therefore, it is recommended that Boozt investigate and analyse their goods to change how Boozt allocates items to the refill locations. Furthermore, Boozt should follow Sueters' suggestion (2023) of staying between 2-5 classes when deciding the number of classes to divide the goods into. Moreover, the amount of criteria on which the goods should be classed should be two. This is based on the comparisons made in the literature review between the different authors, Ravinder and Misra (2016), Thakkar (2021), Güvenir and Erel (1998) and Flores and Whybark (1986). With this in mind, a suggested bi-criteria matrix has been created for Boozt to potentially split its goods into three categories using an ABC-FSN matrix, as shown in Table 5.2. Here, the classes are split into three classes, class 1 consists of CF, BF, AF, AS and AN, class 2 consists of CS, BS and BN and finally, class 3 being CN. The fast-moving, slow-moving and non-moving items should not follow the classifications regarding turnover ratio for those three categories. Instead, it is recommended that Boozt do its own analysis by comparing the turnover ratio between its own products and make conclusions from that. This is because the e-commerce market has a higher demand fluctuation than other markets. Therefore, the definitions in the literature review for the turnover ratio are inaccurate since they look at annual demand instead of more frequent demand, which is needed in the e-commerce market. Lastly, for the A, B and C categorisation, Boozt should follow the classical division that exists in the literature.

Table 5.2: ABC-FSN matrix recommendation.

ABC/FSN Matrix			
	F	S	N
A	AF	AS	AN
B	BF	BS	BN
C	CF	CS	CN

AF = Fast moving items in Group A
BF = Fast moving items in Group B
CF = Fast moving items in Group C
AS = Slow moving items in Group A
BS = Slow moving items in Group B
CS = Slow moving items in Group C
AN = Non-moving items in Group A
BN = Non-moving items in Group B
CN = Non-moving items in Group C

5.2 Value Stream Map and Swimlane Diagram

By creating both the VSM and the Swimlane diagram, a better understanding of Boozt's supply chain is provided, where bottlenecks can be located in both maps but in different ways, which will be discussed later in this chapter. Firstly, the structure of the VSM map will be described and analysed, followed by an analysis of the Swimlane diagram. Finally, these two maps will be compared to draw conclusions from what the two maps convey from Boozt's inbound processes.

The structure of the VSM was designed based on empirical data from Chapters 4.2 and 4.3. The concept of VSM is described by Boozt's having its suppliers deliver daily to Boozt's warehouse and add goods to the inventory. From the moment the goods come in, certain processes are used to move the goods through the warehouse, and these are described by C/Ts, which result in the goods being shipped to the customers on a daily basis. According to the scope of our research, the processes were divided into receiving, sorting, VAS, put-away, and picking. The C/T in the receiving process (95.33s) is calculated by adding the C/T of unloading pallets from the truck with the C/T of scanning and labelling for one pallet. The C/T regarding the sorting and VAS process (571.4s) is calculated by summing the C/T of VAS time per SKU with the C/T of sorting time per SKU. Thereafter, the C/T regarding the put-away (62.42s) describes the put-away time for each bin at the Autostores. Additionally, the 85.14 hours is the time pallets stand idle at the VAS/Sorting area, combined with the idle time for acceptable pallets after receiving and until putaway. Furthermore, the value-added time ratio is calculated by the total inbound value-added time divided by the waiting lead time, resulting in Figure 5.1.

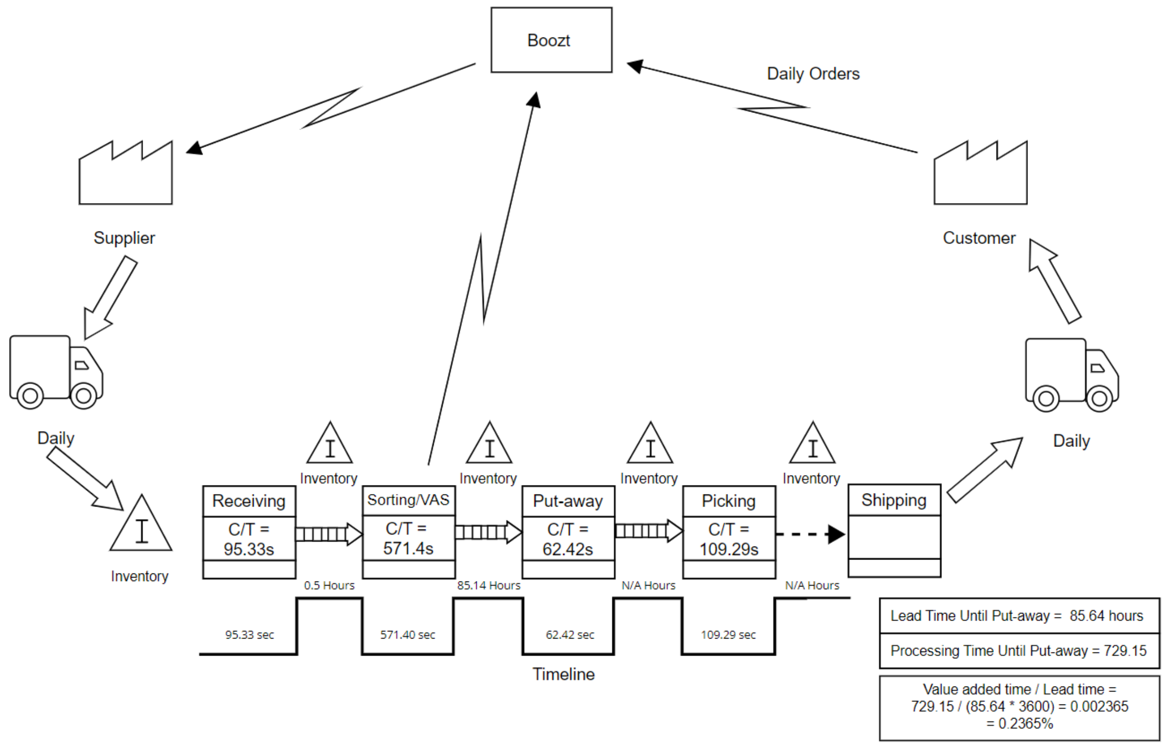

Figure 5.1: As-is VSM of Boozt's warehouse processes.

Figure 5.1 shows that the value-added time ratio is very low, 0.2365%, in the as-is VSM. It should be noted that the VSM only consists of data until the inbound processes are done due to the fact that it stays within the scope of this research paper. Therefore, only those processes will be analysed, and the non-value-adding activities, such as idle time, value-adding time, and cycle times, will not be investigated beyond the put-away process. Furthermore, the Sorting/VAS process was added as a core process in Boozt's warehouse due to both the observations at the warehouse, there was a constant presence of pallets required to be sorted or checked by VAS. Furthermore, the Logistics Project Manager also mentioned that these areas always have pallets. Therefore, it will be treated as a core process, not a situational one in Boozt's inbound flow.

By the recommendations of Langstrand (2016), the first step should be to analyse the as-is VSM and look for imbalances. With this said, after the as-is VSM was created, there was a clear imbalance in Boozt's inbound process. The cycle times of receiving and putaway are both relatively similar, however, looking at the Sorting/VAS cycle time, there is a big difference, which creates an imbalance in the cycle times. Moreover, the non-value-adding times also have a big difference in time, whereas the time a pallet stands idle in the inbound area is only 0.5 hours. The time pallets stand idle at the VAS/Sorting area, combined with the idle time for acceptable pallets after receiving and until putaway, is 71.5 + 13.64 hours, resulting in 85.14 hours. Part of the reason the acceptable pallets are standing there for 71.5 hours is due to the C/T for the putaway process. Another reason is that there is no need for Boozt to make this C/T quicker, which allows Boozt to have this idle time. This is because it does not affect the speed at which the customer receives their order since only the goods that are physically in the Autostore are available for order.

However, the 13.64 hours and the whole sorting/VAS process are causing an imbalance in the value stream. This takes both time and manpower from Boozt and could be reduced. As mentioned, this process is mainly due to having to sort or correct the orders from suppliers. Therefore, one of the ways to reduce this process would be to develop better supplier relationships and deal with the different suppliers better. If Boozt develops better relationships and deals with their suppliers, such as making stricter rules regarding these shipments, the number of pallets needing sorting/VAS may be reduced. Boozt's supplier relationships will be further analysed in Chapter 5.4, however, if the sorting/VAS process is removed due to the potential improvements, then the to-be VSM map, as shown in Figure 5.2.

As shown in Figure 5.2, the value-added time ratio is 0.06% which is worse than before. This is due to the as-is map including the cycle time for the VAS processes as value-adding, which is misleading. This is because the whole process is something extra that Boozt does not want to exist since it consumes more manpower and time than if this process did not exist. Additionally, the average time pallets standing idle at VAS/Sorting is removed, and the idle hours are reduced. Furthermore, removing the VAS/Sorting process makes the balance throughout the inbound flow evener. Therefore, the to-be VSM map will result in a more efficient inbound flow for Boozt.

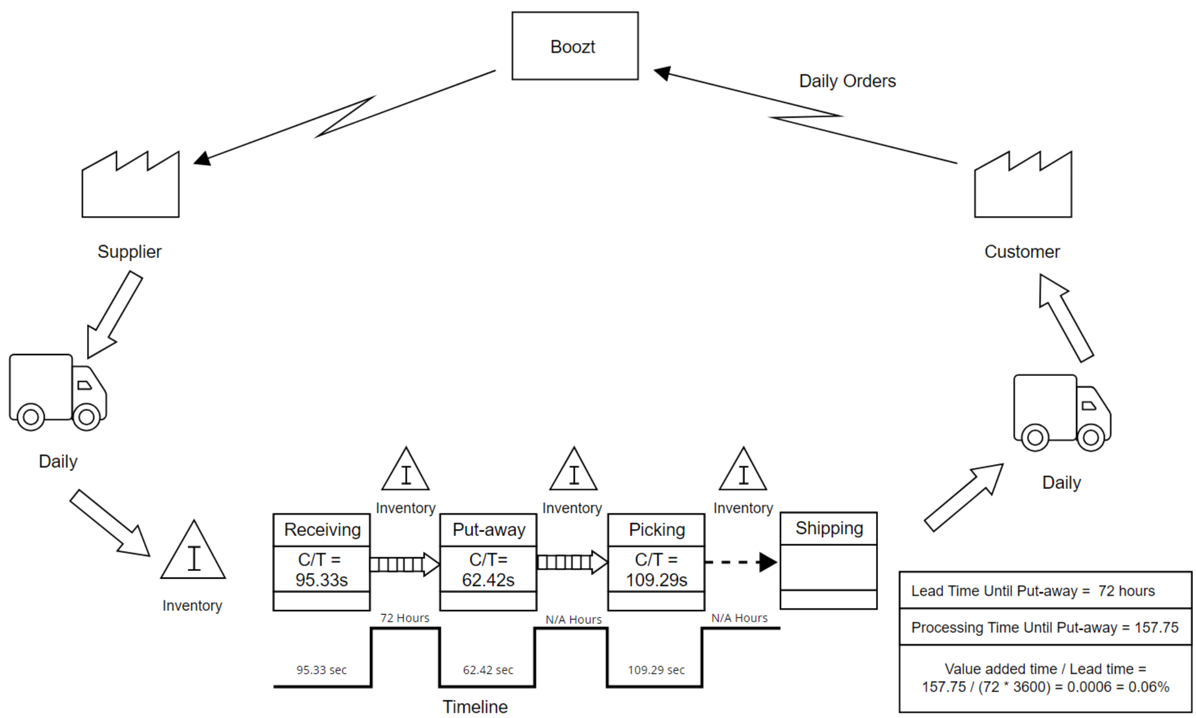

Figure 5.2: To-be VSM of Boozt's warehouse processes.

Looking at the swimlane diagram in the empirical chapter, Figure 4.5, and remembering that Damelio (2011) states that swimlanes help locate the work being done in the process and determine the type. Therefore, by concentrating on the process leading up to the goods being placed in the Autostore, similar conclusions to those found in the VSM analysis can be made. The amount of work being done and decisions having to be made due to this existing process are plenty. First, the sorting has to be decided upon, and also, if the goods require VAS, however, if the goods require sorting, they will then be sorted, and then another control for if the goods require VAS will be done. However, if the goods are scanned and acceptable and then are sent directly to one of the Autostores, the operators will do another check to see if it has to go back to VAS. This results in a lot of back and forth regarding the inbound flow, for example, if it has been identified that VAS is required on a pallet that has been delivered to Autostore 3, then it would mean that an operator would have to drive all the way to Autostore 3 to pick it back up and deliver it to VAS which results in extra handling and movement of goods.

Moreover, it can be seen through the Swimlane diagram that this further strengthens the argument that if the process of sorting/VAS can be reduced or optimally removed, then it would lead to reductions in handling, decision making, movement of goods and lead to the inbound flow being more efficient. For example, if one were to remove the sorting/VAS process completely in Boozt's current warehouse process, it would look as shown in Figure 5.3.

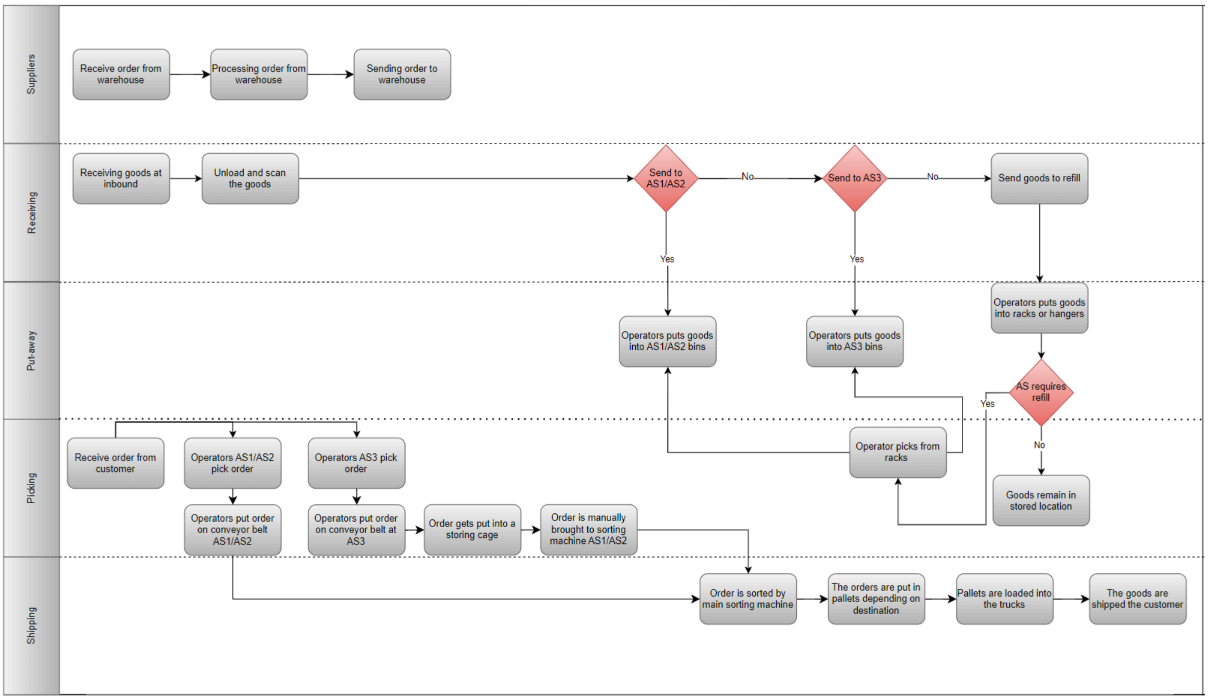

Figure 5.3: To-be Swimlane diagram of Boozt's warehouse processes.

When comparing the amount of decision-making and general flow in the to-be swimlane with the as-is, the maps are simpler and have fewer process steps in decision-making.

In line with Gardner and Cooper (2003), the advantages of mapping were seen through the two maps developed. It also allows a clearer view that helps with the deeper analysis of Boozt's operations. With the analysis of both maps being complete, it reveals a clear problem that is disrupting the inbound flow and efficiency of Boozt's warehouse processes which is the VAS and Sorting process. Removing or reducing the occurrence of this process will make the inbound flow more efficient. However, removing the VAS/Sorting process completely may not be possible, and only reducing the process would be more realistic. Despite that, this would mean that the process will look like Figure 5.3 more frequently.

5.3 The Suppliers Evaluation by AHP-TOPSIS

The analysis of the suppliers will be done by the AHP-TOPSIS approach. As Hanine et al. (2016) stated, AHP is a well-known technique for structuring the problem, and TOPSIS is one of the most efficient ways to rank the suppliers. Therefore, using this hybrid approach will lead to great results, as was seen in the papers of Jiménez-Delgado et al. (2020) and Haji et al. (2022). The hybrid approach will include several steps, such as the initial procedure, the calculations of the results, and the analysis of the AHP-TOPSIS approach and results. The initial procedure will provide the steps that must be taken and how the literature approaches the AHP-TOPSIS method with certain aspects considered. Then, the calculations will be done based on the results from the form that has been sent out, followed by a thorough analysis of the calculations and results. Consequently, the analysis provides a list of suppliers ranked by certain criteria and how well the suppliers perform.

5.3.1 Initial Procedure

Using the AHP-TOPSIS approach, suppliers are ranked based on criteria chosen from literature and interviews. The initial steps of the AHP-TOPSIS approach were collecting data from Boozt's warehouse operations department that would assess which criteria are important when ranking the suppliers. These criteria are based on the literature and the interviews with the department. As Kumar et al. (2019) stated, AHP requires data on experience, knowledge, and opinion, which can be subjective for each decision-maker. Interviewing the warehouse department prevents bias by discussing the criteria with different persons. However, these unstructured interviews are from the same department, which could lead to a more biased result. The analysis includes the inbound team of Boozt, which has filled out the ratings of the criteria and applied how these criteria would be ranked among the suppliers. Three studies (Agarwal et al., 2011; Hald & Ellegaard, 2011; Zhang et al., 2020) have concluded that various criteria are involved in MCDM models, such as speed, delivery performance, price, quality and reliability. Within the TOPSIS approach, suppliers were chosen based on quality, delivery time, costs and flexibility. Park et al. (2010) added that suppliers can be valued based on their categories, capabilities, performance and collaborative relationships.

In order to apply the framework in Figure 3.5, one criterion in each of those areas mentioned by Park et al. (2010) is recommended to be included in the supplier evaluation. Therefore, one criterion per category was considered when deciding on criteria for the AHP form. As mentioned, criteria were obtained from interviews with Boozt's employees to satisfy Boozt's requirements and what values their suppliers should have. The previously described criteria from the literature were compared to the results of the interview, where corresponding criteria and frequently discussed criteria were chosen. The criteria found in the literature and acknowledged by the interviewees were trust, responsibility, and communication, whereas product data and delivery reliability came forth from the interviews as important criteria for evaluating suppliers. One criterion that may have been interesting to analyse would be price. However, this criterion was not included due to the nature of Boozt's products. Boozt's products are very individualistic; for example, the suppliers do not all supply the same identical product, such as copper wires. Therefore, comparing the prices between the different vendors is not useful because, for example, comparing clothing like "Nike" to "H&M" Nike is the more expensive choice. However, Nike is not replaceable by H&M and vice versa since they sell different clothing. Therefore, the price would only be an interesting criterion to research when there are multiple vendors that can offer identical goods, for example, if there was an option to choose between "Nike1" and "Nike2". As a result, a certain set of criteria has been created, as shown in Table 5.3. These chosen criteria will be the basis for the AHP-TOPSIS approach to evaluate the supplier's performance.

Table 5.3: The definitions of the criteria.

Criteria	**Definitions**
Trust	Sharing ideas and technology where it is not in a self-serving way while maintaining mutual respect, honesty and transparency.
Delivery Reliability	The ratio of the number of deliveries made without errors regarding time and quantity to the number of deliveries in a contract.
Responsibility	Taking responsibility means acknowledging and accepting accountability for one's actions, decisions, and consequences, whether positive or negative.
Communication	How responsive the suppliers are when communicating with Boozt when necessary
Product Data	How well the supplier performs in adding product data to their deliveries.

Following the steps from the literature, the next step in the procedure is to construct the hierarchical structure based on the MCDM's goal. This is also done to ensure a logical connection.

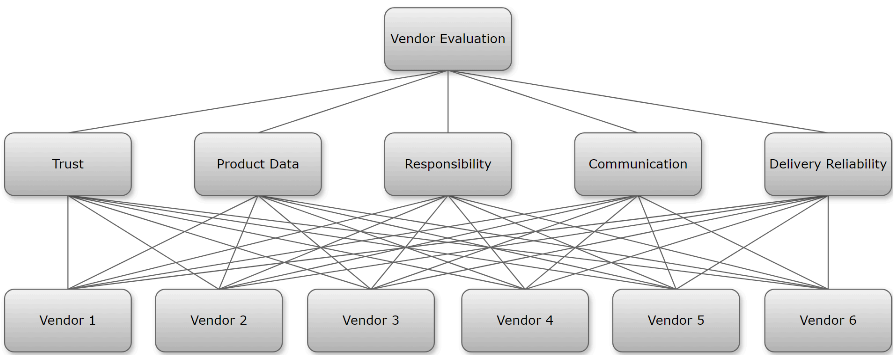

Figure 5.4: Hierarchical structure of the AHP-TOPSIS at Boozt.

The criteria from Table 5.3 were put in a form as shown in Table 5.4. These forms were sent out to the inbound team of Boozt and rated the importance of these criteria compared to each other between 1 to 9, translating to equally preferred to extremely preferred, following the preference ranking in the literature shown previously in Chapter 3, Table 3.2. Once the criteria were rated, the vendors were rated by rating them as Very Dissatisfied to Exceptionally Satisfied based on each criterion, as shown in Table 5.5. Therefore, the results will include the rating of the criteria compared to each other and the rating of the vendors for each criterion. Below is the template of the forms sent to Boozt's inbound team.

Table 5.4: The rating of the criteria (left) and the rating of the vendors (right).

Criterias compared to eachother																	
									Equal								
Trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Delivery reliability
Trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Communication
Trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Responsibility
Trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product data
Delivery reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Communication
Delivery reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Responsibility
Delivery reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product data
Communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Responsibility
Communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product data
Responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product data

Fill out the form form and rate the suppliers between 1-9 respectively very dissatisfied to exceptionally satisfied.

	Trust	Responsibility	Delivery Reliability	Communication	Product data
Vendor 1					
Vendor 2					
Vendor 3					
Vendor 4					
Vendor 5					
Vendor 6					

1. Very Dissatisfied; 2. Very Dissatisfied; 3. Slightly Dissatisfied
4. Neutral; 5. Slightly satisfied; 6. Satisfied
7. Very Satisfied; 8. Extremely Satisfied; 9. Exceptionally Satisfied

5.3.2 Calculations of the Results

The calculations of the AHP-TOPSIS approach required the inbound team to fill out the forms from Table 5.4. As a result, the criteria comparison in the form from the initial procedure of Table 5.4 were answered by the inbound team as shown in Table 5.5. Based on a quick overview, it is noticeable from the table that trust is most of the time valued as less important and where delivery reliability and product data is often seen as more important than other criteria.

Table 5.5: Rating of the criteria from the inbound team of Boozt

Criterias compared to eachother																		
									Equal									
Trust	9	8	7	6	5	4	3	2	1	2	3	4		6	7	8	9	Delivery reliability
Trust	9	8	7	6	5	4	3	2	1	2	3	4		6	7	8	9	Communication
Trust	9	8	7	6	5	4	3	2	1	2		4	5	6	7	8	9	Responsibility
Trust	9	8	7	6	5	4	3	2	1	2	3	4		6	7	8	9	Product data
Delivery reliability	9	8	7	6		4	3	2	1	2	3	4	5	6	7	8	9	Communication
Delivery reliability	9	8	7	6	5	4	3	2		2	3	4	5	6	7	8	9	Responsibility
Delivery reliability	9	8	7	6	5	4	3	2		2	3	4	5	6	7	8	9	Product data
Communication	9	8	7	6		4	3	2	1	2	3	4	5	6	7	8	9	Responsibility
Communication	9	8	7	6	5	4	3	2	1	2	3	4		6	7	8	9	Product data
Responsibility	9	8	7	6	5	4	3	2	1	2	3	4		6	7	8	9	Product data

The inbound team's results were then transformed into a pairwise comparison matrix to begin the AHP calculations. The constructed matrix can be seen in Table 5.6.

Table 5.6: Pairwise comparison of the criteria.

Criteria	Trust	Responsibility	Delivery Reliability	Communication	Product Data
Trust	1	1/3	1/5	1/5	1/5
Responsibility	3	1	1	1/5	1/5
Delivery Reliability	5	1	1	5	1
Communication	5	5	1/5	1	1/5
Product Data	5	5	1	5	1

Following the AHP calculation procedure it is then time to follow the steps presented in the literature in order to calculate the weight for each criterion. First step of this is to sum each column of the matrix which resulted in different sums as shown in Table 5.7.

Table 5.7: Sum of each column of the pairwise comparison

Criteria	Trust	Responsibility	Delivery Reliability	Communication	Product Data
Trust	1	1/3	1/5	1/5	1/5
Responsibility	3	1	1	1/5	1/5
Delivery Reliability	5	1	1	5	1
Communication	5	5	1/5	1	1/5
Product Data	5	5	1	5	1
SUM =	19	37/3	17/5	57/5	13/5

Naturally, the next step in the process is to normalise the matrix, which is done by dividing each value by the sum that was calculated for the column the value is in. Doing this for each cell gives a normalised pairwise comparison matrix as is seen in Table 5.8. Observe that the numbers are still in fractions and have yet to be converted into decimals numbers.

Table 5.8: Normalised pairwise comparison matrix.

Criteria	Trust	Responsibility	Delivery Reliability	Communication	Product Data
Trust	1/19	1/37	1/17	1/57	1/13
Responsibility	3/19	3/37	5/17	1/57	1/13
Delivery Reliability	5/19	3/37	5/17	25/57	5/13
Communication	5/19	15/37	1/17	5/57	1/13
Product Data	5/19	15/37	5/17	25/57	5/13

Next, the values in each cell are converted to decimals and the average value for each row is calculated. The average value per row is calculated in Table 5.9. This gives the weights for each criterion, which shows how important they are compared to each other. Lastly, as a control check that the calculations have been done correctly, the sum of each column should equal 1, which was also controlled.

Table 5.9: Normalised pairwise comparison matrix and the average value per row.

Criteria	Trust	Responsibility	Delivery Reliability	Communication	Product Data	Average Per Row
Trust	0.05263	0.02703	0.05882	0.01754	0.07692	0.04659
Responsibility	0.15789	0.08108	0.29412	0.01754	0.07692	0.12551
Delivery Reliability	0.26316	0.08108	0.29412	0.43860	0.38462	0.29232
Communication	0.26316	0.40540	0.05882	0.08772	0.07692	0.17840
Product Data	0.26316	0.40540	0.29412	0.43860	0.38462	0.35718
Sum	1	1	1	1	1	1

Looking at Table 5.9, the AHP calculations show the criterion weights for trust, responsibility, delivery reliability, communication, and product data are 0.04659, 0.12551, 0.29232, 0.17840 and 0.35718.

Lastly, in line with the literature, a consistency check is needed to be done in order to see if the inbound team has answered consistently. However, it should be noted that even if the consistency ratio is above 0.1, it does not necessarily mean that the results are invalid. The first step of the consistency check is to do the scalar product of the original pairwise matrix and the calculated weights, as was described in the literature review chapter 3.3.1.1. Furthermore, Table 5.10 shows the structure of how the scalar product between the row and column is to be done.

Table 5.10: *The original pairwise matrix multiplied by the calculated criteria weights by doing scalar product, row-column.*

Criteria	Trust	Responsibility	Delivery Reliability	Communication	Product Data
Trust	1	1/3	1/5	1/5	1/5
Responsibility	3	1	1	1/5	1/5
Delivery Reliability	5	1	1	5	1
Communication	5	5	1/5	1	1/5
Product Data	5	5	1	5	1

·

Criteria Weights
0.04659
0.12551
0.29232
0.17840
0.35718

Next, calculating the scalar product between the row and the criteria weights column gives the value for each scalar product, as follows.

$$1 * 0.04659 + \frac{1}{3} * 0.12551 + \frac{1}{5} * 0.29232 + \frac{1}{5} * 0.1784 + \frac{1}{5} * 0.35718 = 0.2540$$
$$3 * 0.04659 + 1 * 0.12551 + 1 * 0.29232 + \frac{1}{5} * 0.1784 + \frac{1}{5} * 0.35718 = 0.6650$$
$$5 * 0.04659 + 1 * 0.12551 + 1 * 0.29232 + 5 * 0.1784 + 1 * 0.35718 = 1.8999$$
$$5 * 0.04659 + 5 * 0.12551 + \frac{1}{5} * 0.29232 + 1 * 0.1784 + \frac{1}{5} * 0.35718 = 1.1688$$
$$5 * 0.04659 + 5 * 0.12551 + 1 * 0.29232 + 5 * 0.1784 + 1 * 0.35718 = 2.402$$

Dividing each of these numbers by the corresponding weight for that scalar product will give 5.452, 5.298, 6.499, 6.552 and 6.725, which can be seen below.

$$\frac{0.2540}{0.04659} = 5.452; \frac{0.6650}{0.12551} = 5.298; \frac{1.8999}{0.29232} = 6.499; \frac{1.1688}{0.1784} = 6.552; \frac{2.402}{0.35718} = 6.725$$

Next, λ_{max} is obtained by dividing the sum of these values by the number of analysed criteria.

$$\frac{5.452+5.298+6.499+6.552+6.725}{5} = 6.1053 = \lambda max$$

6.1053 is the λ max, which can be found in the consistency index by applying the following formula.

$$Consistency\ Index = \frac{\lambda max - n}{n-1} = \frac{6.1053 - 5}{5 - 1} = 0.2763$$

Lastly, the consistency ratio is calculated using the formula below, and the random index value which is taken directly from Table 3.8 in the literature review. The ratio given is 0.247, which is greater than the acceptable result of 0.1.

$$Consistency\ Ratio = \frac{Consistency\ Index}{Random\ Index} = \frac{0.2763}{1.12} = 0.247 > 0.1$$

After applying AHP, the criteria weights are calculated and can be used to rank the suppliers using the TOPSIS method. The inbound team rated each supplier by each criterion, as shown in Table 5.11. These results will be used together with the calculated weights from the AHP method to rank the vendors.

Table 5.11: Ranking of the vendors regarding the criteria.

Fill out the form form and rate the suppliers between 1-9 respectively very dissatisfied to exceptionally satisfied.					
	Trust	Responsibility	Delivery Reliability	Communication	Product data
Vendor 1	5	6	1	4	3
Vendor 2	7	4	7	4	6
Vendor 3	5	1	7	4	3
Vendor 4	7	4	7	4	6
Vendor 5	8	7	7	4	6
Vendor 6	8	1	7	4	6
1. Very Dissatisfied; 2. Very Dissatisfied; 3. Slightly Dissatisfied					
4. Neutral; 5. Slightly satisfied; 6. Satisfied					
7. Very Satisfied; 8. Extremely Satisfied; 9. Exceptionally Satisfied					

The first step of the TOPSIS approach is to use the values of Table 5.11 and calculate the normalised matrix using Formula 1. As a result, a normalised matrix is obtained, as shown in Table 5.12. The calculation of vendor 1 for trust is done using Formula 1, where all the values of the vendors regarding trust are used to calculate the normalised matrix as seen in Formula 2. These calculations are done repetitively until all the cells have been calculated, resulting in Table 5.12.

$$\overline{X}_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^2}} \quad (1)$$

$$\overline{X}_{1T} = \frac{X_{1T}}{\sqrt{\sum_{i=1}^{n} X_{iT}^2}} = \frac{5}{\sqrt{5^2+7^2+5^2+7^2+8^2+8^2}} = 0,300964663 \quad (2)$$

Table 5.12:Normalised matrix.

	Criteria				
	Trust	Responsibility	Delivery Reliability	Communication	Product data
Vendor 1	0,30096463	0,55001910	0,06375767	0,40824829	0,23570226
Vendor 2	0,42135049	0,36667940	0,44630370	0,40824829	0,47140452
Vendor 3	0,30096463	0,09166985	0,44630370	0,40824829	0,23570226
Vendor 4	0,42135049	0,36667940	0,44630370	0,40824829	0,47140452
Vendor 5	0,48154341	0,64168895	0,44630370	0,40824829	0,47140452
Vendor 6	0,48154341	0,09166985	0,44630370	0,40824829	0,47140452

After the normalised matrix is done, the weights of each criterion are added to the table and are used to calculate the weighted normalised matrix. This is done by multiplying the weights of each criterion by the normalised value that resulted in the weighted normalised matrix. For example, Formula 3 and 4 explain the formula used for calculating the weighted normalised value of vendor 1 regarding trust. These calculations resulted in the weighted normalised matrix, as shown in Table 5.13.

$$V_{ij} = \overline{X_{ij}} * W_j \quad (3)$$

$$V_{1T} = \overline{X_{1T}} * W_T = 0,30086463 * 0,04658981 = 0,01402189 \quad (4)$$

Table 5.13: Weighted normalised matrix.

	Criteria				
	Trust	Responsibility	Delivery Reliability	Communication	Product data
Weight	**0,04658981**	**0,12551208**	**0,29231370**	**0,17840584**	**0,35717857**
Vendor 1	0,01402189	0,06903404	0,01863724	0,07283388	0,08418780
Vendor 2	0,01963064	0,04602269	0,13046069	0,07283388	0,16837559
Vendor 3	0,01402189	0,01150567	0,13046069	0,07283388	0,08418780
Vendor 4	0,01963064	0,04602269	0,13046069	0,07283388	0,16837559
Vendor 5	0,02243502	0,08053971	0,13046069	0,07283388	0,16837559
Vendor 6	0,02243502	0,01150567	0,13046069	0,07283388	0,16837559

Then, the ideal worst and ideal best values are found by calculating each criterion's maximum (V+) and minimum (V—) values regarding the vendors. These maximums and minimums are calculated by Formula 4 and 5, resulting in Table 5.14, which found the ideal worst and best values of the columns. For example, this led to the column trust's maximum value (0,02243502) and minimum (0,01402189).

$$V^+ = max(V_{ij}) \quad (4)$$

$$V^- = min(V_{ij}) \quad (5)$$

Table 5.14: Worst and best value matrix.

	Criteria				
	Trust	Responsibility	Delivery Reliability	Communication	Product data
Weight	0,04658981	0,12551208	0,29231370	0,17840584	0,35717857
Vendor 1	0,01402189	0,06903404	0,01863724	0,07283388	0,08418780
Vendor 2	0,01963064	0,04602269	0,13046069	0,07283388	0,16837559
Vendor 3	0,01402189	0,01150567	0,13046069	0,07283388	0,08418780
Vendor 4	0,01963064	0,04602269	0,13046069	0,07283388	0,16837559
Vendor 5	0,02243502	0,08053971	0,13046069	0,07283388	0,16837559
Vendor 6	0,02243502	0,01150567	0,13046069	0,07283388	0,16837559
V+	0,02243502	0,08053971	0,13046069	0,07283388	0,16837559
V-	0,01402189	0,01150567	0,01863724	0,07283388	0,08418780

The Euclidean distances can be calculated by calculating every column's maximum and minimum values. These are called the separation points from the Positive Ideal Point and Negative Ideal point between the alternatives. The Positive Ideal Point and Negative Ideal

Point are calculated by Formula 6 and 7. Using each vendor's criteria value and subtracting it from the Positive Ideal Point and Negative ideal point, the Euclidean distances are calculated as shown in Table 5.15. For example, the Positive Ideal Point for Vendor 1 can be calculated by Formula 8. This logic will calculate every other cell according to these formulas.

$$S_i^+ = \left[\sum_{j=1}^{m} (V_{ij} - V_j^+)^2\right]^{0.5} \quad (6)$$

$$S_i^- = \left[\sum_{j=1}^{m} (V_{ij} - V_j^-)^2\right]^{0.5} \quad (7)$$

$$S_i^+ = \left[\sum_{j=1}^{m} (V_{ij} - V_j^+)^2\right]^{0.5} = \left[(0,014 - 0,022)^2 + (0,069 - 0,081)^2 + ...\right]^{0.5} = 0,014 \quad (8)$$

Table 5.15: Euclidean distance.

	Criteria						
	Trust	Responsibility	Delivery Reliability	Communication	Product data	Euclidean distance	
Weight	0,04658981	0,12551208	0,29231370	0,17840584	0,35717857	Si+	Si-
Vendor 1	0,01402189	0,06903404	0,01863724	0,07283388	0,08418780	0,14069552	0,05752837
Vendor 2	0,01963064	0,04602269	0,13046069	0,07283388	0,16837559	0,03463076	0,14427387
Vendor 3	0,01402189	0,01150567	0,13046069	0,07283388	0,08418780	0,10919736	0,11182344
Vendor 4	0,01963064	0,04602269	0,13046069	0,07283388	0,16837559	0,03463076	0,14427387
Vendor 5	0,02243502	0,08053971	0,13046069	0,07283388	0,16837559	0,00000000	0,15629634
Vendor 6	0,02243502	0,01150567	0,13046069	0,07283388	0,16837559	0,06903404	0,14022428
V+	0,02243502	0,08053971	0,13046069	0,07283388	0,16837559		
V-	0,01402189	0,01150567	0,01863724	0,07283388	0,08418780		

The results of Table 5.15 can be used to calculate the performance of each vendor by Formula 9. For example, Formula 10 provides the performance rating of Vendor 1 by putting the Euclidean distances in the formula. Doing this repeatedly for each vendor, the performance rating for each vendor is known and can be ranked.

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-} \quad (9)$$

$$P_1 = \frac{S_1^-}{S_1^+ + S_1^-} = \frac{0,058}{0,141+0,058} = 0,290 \quad (10)$$

Table 5.16: Performance rank.

	Criteria								
	Trust	Responsibility	Delivery Reliability	Communication	Product data	Euclidean distance			
Weight	0,04658981	0,12551208	0,29231370	0,17840584	0,35717857	Si+	Si-	Pi	Rank
Vendor 1	0,01402189	0,06903404	0,01863724	0,07283388	0,08418780	0,14069552	0,05752837	0,29021915	6
Vendor 2	0,01963064	0,04602269	0,13046069	0,07283388	0,16837559	0,03463076	0,14427387	0,8064289567	3
Vendor 3	0,01402189	0,01150567	0,13046069	0,07283388	0,08418780	0,10919736	0,11182344	0,5059407983	5
Vendor 4	0,01963064	0,04602269	0,13046069	0,07283388	0,16837559	0,03463076	0,14427387	0,8064289567	2
Vendor 5	0,02243502	0,08053971	0,13046069	0,07283388	0,16837559	0,00000000	0,15629634	1	1
Vendor 6	0,02243502	0,01150567	0,13046069	0,07283388	0,16837559	0,06903404	0,14022428	0,6701013321	4
V+	0,02243502	0,08053971	0,13046069	0,07283388	0,16837559				
V-	0,01402189	0,01150567	0,01863724	0,07283388	0,08418780				

Finally, the vendors are ranked by sorting the performance rating in Table 5.16. Vendor 5 was number one, followed by Vendors 4, 2, 6, 3, and lastly, Vendor 1.

5.3.3 Analysis of the Results

The analysis of the supplier evaluation began with identifying the criteria which were seen as most important to Boozt. These criteria included trust, delivery reliability, responsibility, communication, and product data, which have been given weight using the AHP method. Based on Table 5.9, product data and delivery reliability have been identified as the most important criteria, respectively 0.35 and 0.29. Therefore, in order to be a good supplier of Boozt, these criteria are the most important for Boozt's suppliers to perform well. Communication and responsibility criteria, respectively 0.18 and 0.13, are less important than product data and delivery reliability. Although scoring lower, these criteria are still important in measuring the supplier's performance. Lastly, trust is seen by Boozt as the least important, scoring 0.047, therefore stating trust is not as important as the other criteria.

Tidy, Wang and Hall (2016) stated that key aspects of SRM are trust and communication. Additionally, it is mentioned that trust is a major factor in achieving a good relationship between a company and a supplier (Al-Abdallah, Abdallah and Hamdan, 2014; Dash, Pothal and Tripathy, 2018; Moeller, Fassnacht and Kiose, 2006; Park, et al., 2010; Tidy, Wang and Hall 2016; Zairi and Al-Mashari 2002). These are important criteria that are required to maintain the relationships with the suppliers but are scored quite low within the weight calculations, which were made from the judgments of Boozt. Nonetheless, communication remains relatively high within the ranking of the criteria, making it more in line when compared to the literature. Also, the criteria ranking could depend on the sort of industry in which criteria seem valuable for certain sectors. Within this context, e-commerce and fashion, it could be that certain criteria, such as product data and delivery reliability, are more valuable than criteria, such as trust or responsibility. As a result, for Boozt's specific case, this means that product data is the highest, delivery reliability second, communication third, responsibility fourth and trust fifth when looking at their vendors, as shown in Table 5.17.

Table 5.17: *Rank and weight of each criterion.*

Criteria	Product Data	Delivery Reliability	Communication	Responsibility	Trust
Rank	1	2	3	4	5
Weight	0,357	0,292	0,178	0,126	0,047

After the weights were calculated, the consistency ratio had to be calculated to check whether it was acceptable. The calculated ratio was 0.247, while the acceptable result was 0.1. Thus, the calculated ratio is higher than the provided result. This means that the inbound team did not score the form consistently enough.

However, due to the fact that there are many criteria to be compared, the chance of rating inconsistently increases. Furthermore, due to the criteria being qualitative, there may have been a reason for it to be inconsistent. For example, if product data is rated 3 over trust and responsibility, then for it to be consistent throughout the rating, it would mean that trust and responsibility should be equal to each other. However, these qualitative criteria are not as white and black as quantitative, which may further increase inconsistencies. Lastly, since a team was filling out one pairwise comparison, the probability of discussions between the comparisons was very high, which could increase the rating inconsistencies. With these three arguments, the 0.247 consistency ratio will therefore be accepted.

Finally, using the hybrid AHP-TOPSIS approach, the weights could be used to calculate the performance of each supplier on each criterion. Table 5.18 shows the results of the AHP-TOPSIS approach, which is based on the weighted criteria of trust, responsibility, delivery reliability, communication, and product data regarding vendors 1 until 6. Vendor 5 has the best performance among the other vendors, where vendors 4 and 2 are equally performing well, followed by Vendor 6. Vendors 3 and 1 are underperforming in this particular situation.

Table 5.18: Final ranking of the vendors.

Vendors	Vendor 5	Vendor 4	Vendor 2	Vendor 6	Vendor 3	Vendor 1
Rank	1	2	3	4	5	6
Performance	1,000	0,806	0,806	0,670	0,506	0,290

The reason for Vendor 5 performing so well is based on the higher scores it has received together with Vendors 4 and 2, where none of these vendors have scored lower than a 4, meaning they are performing neutral, as shown in Table 5.19. However, Vendor 6 has been underperforming on responsibility with a score of 1, meaning very dissatisfied, leading to a lower rank. Vendor 3 has been underperforming in terms of responsibility and product data, leading to a slightly lower score than Vendor 6. Vendor 1 scored 1, meaning very dissatisfied, on delivery reliability and product data, which weighed the heaviest, thus scoring the lowest. From these results, it can be concluded that Vendors 1 and 3 have to increase their performance, Vendor 1 has to perform better on product data and delivery reliability, whereas Vendor 3 has to perform significantly better on responsibility and product data. Then, vendor 6 has to take much more responsibility than the current situation and finally, vendor 5 could make minor improvements in communication, whereas Vendors 4 and 2 could make minor adjustments in responsibility and communication.

Table 5.19: Coloured coding of the vendors and its criteria.

Weight	0,04658981	0,12551208	0,29231370	0,17840584	0,35717857
Criteria	Trust	Responsibility	Delivery Reliability	Communication	Product data
Vendor 1	5	6	1	4	3
Vendor 2	7	4	7	4	6
Vendor 3	5	1	7	4	3
Vendor 4	7	4	7	4	6
Vendor 5	8	7	7	4	6
Vendor 6	8	1	7	4	6

Based on these results, certain vendors must improve their performance regarding the criteria. It would be recommended for Boozt to check the performance of Vendors 1,3 and 6. These vendors are scoring low on criteria such as delivery reliability, product data, and responsibility. For example, if Vendor 1 or 3 would improve their product data, the vendors would already score much higher due to the weights of the criterion. Therefore, a recommendation would be to communicate between the departments and discuss whether these vendors can provide more product data for the warehouse. Moreover, the delivery reliability of Vendor 1 has to be addressed by the company through the departments, where it could even be addressed by showing their delivery reliability compared to the other vendors and making a case for it through this. Lastly, a recommendation would be that Boozt reconsiders the importance of the weights of the criteria when performing an AHP because the literature stated that trust and communication are the most important criteria when valuing the vendors. Therefore, it would be recommended that Boozt reconsiders the rating of the criteria, especially regarding rating communication and trust.

5.4 Supplier Relationships

As mentioned in Chapter 5.2, improving the buyer-to-supplier relationship is one of the ways to reduce the bothersome VAS/sorting processes. It is believed that improving the suppliers and also changing from treating all vendors identically to treating them differently will reduce the VAS/sorting occurrence. This is based on the fact that improving the relationships as well as the performance of the suppliers should result in better deliveries overall for Boozt that will match Boozt's request. Reducing the VAS/sorting process will bring more profit to both Boozt and the vendor in the form of reducing the number of invoices being sent to the vendor as well as the reduction of work needing to be done from Boozt's side to compensate for this resulting in a win-win situation. Therefore, Park, et al. (2010) framework for what type of relationship to have with the suppliers depending on their strategic importance and relationship attractiveness will be applied to Boozt's vendors.

5.4.1 Analysis of Buyer-to-Supplier Relationship Framework

In order to construct the framework of Park et al. (2010), several aspects must be considered. First, the construction of the Kraljic matrix was done where each vendor was decided upon based on the examples of what leverage items, strategic items, non-critical items and bottleneck items contain, which is shown in Figure 3.4. Therefore, the vendors were placed on the matrix depending on the type of items, if the vendor had a high volume or cost, and if it was easy to substitute the suppliers based on Boozt's company strategy. With this said, Vendor 1 was placed in the leverage items quadrant due to the high volume they supply, their items are quite standard and nothing special, and there are alternative suppliers available that could provide similar goods. Vendors 2, 3, 4 and 6 were placed in the top right quadrant due to their goods being on the premium side and are, therefore, high-value goods, they are also strategically important in order for Boozt to keep their strategy to offer premium and high quality brands and they are not easily replaceable due to the brand image these vendors provide. Lastly, vendor 5 was placed in the bottom left quadrant due to the items being standard as well as the volume they are supplying Boozt with is also on the lower side compared to the other vendors, lastly, this vendor does not have an established brand image as vendor 2,3,4 and 6 and does, therefore, easier to replace with alternative suppliers. With these placements, the Kraljic matrix was created as shown in Figure 5.5.

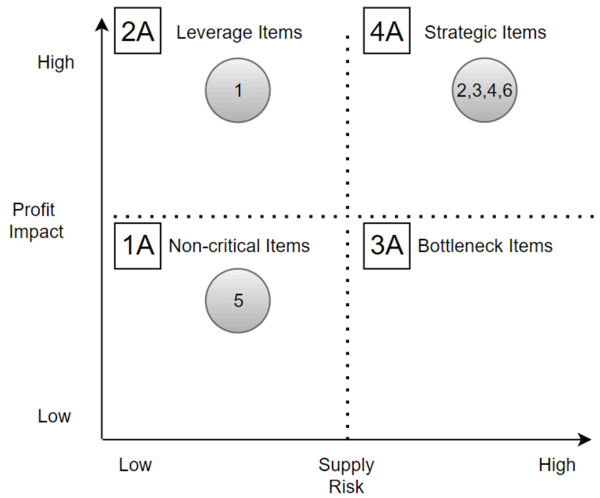

Figure 5.5: Kraljic matrix with the placement of the vendors.

To continue the framework's construction, the vendors must be placed on the purchasing portfolio model. Following the explanation given by Olsen and Ellram (1997) in the literature review regarding the factors affecting the Y-axis, relative supplier attractiveness, and the X-axis, strength of relationship, the vendors were placed in the different quadrants. Vendor 3 was placed in the bottom left quadrant, lack of attractiveness; Vendor 1 was placed in the bottom right quadrant, buyer's attractiveness; and Vendors 2, 4, 5 and 6 were placed in the top right quadrant, mutual attractiveness. This constructs the model, which can be seen in Figure 5.6.

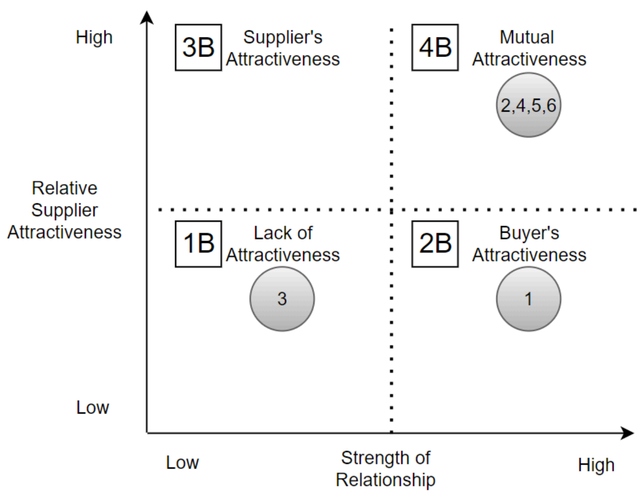

Figure 5.6: Olsen and Ellram purchasing portfolio model with the placement of the vendors.

Combining these two models, following the theory from Park et al. (2010), creates the buyer-to-supplier relationship framework, as can be seen in Figure 5.7.

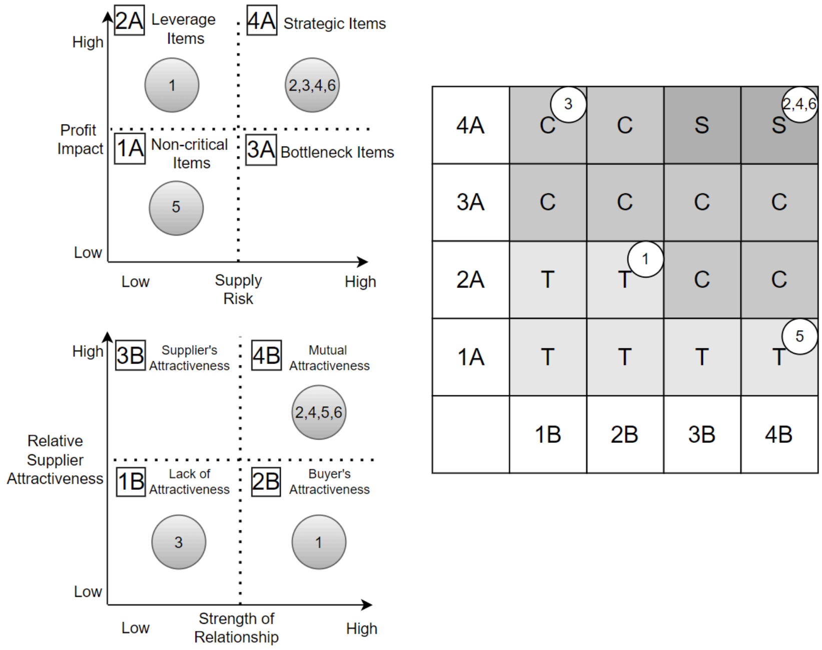

Figure 5.7: Suggested buyer-to-supplier relationship to implement with the vendors, adapted from Park, et al. (2010).

Looking at the framework in Figure 5.7 shows the relationship that Boozt should strive for with these six vendors. Vendors 1 and 5 should have a transactional type of relationship with Boozt, which means that the relationship is from a transactional perspective that would be more impersonal and the duration, often discrete, can repeat over time. Vendor 3 should have a collaborative relationship with Boozt, which tends to be longer term, cooperative, more interpersonal and is likely to operate on a continuous basis. Vendors 2, 4 and 6 should have a strategic relationship with Boozt, which is agreeing to support each other in an effort to help both parties to succeed, sharing resources and increasing efficiencies, thus creating a mission to mutually grow as company's. Therefore, it would be recommended for Boozt to take these relationships into consideration when doing negotiations with the suppliers in order to treat their suppliers differently from each other.

5.4.2 The Treatment of Suppliers Framework

The results from the suggested relationships in the previous chapter and the supplier evaluation of the AHP-TOPSIS approach can be combined together to decide which supplier should be treated by Boozt in the form of improvement, maintenance, collaboration or prime, as shown in Figure 5.8. The x-axis ranges from bad to good to excellent, which translates respectively to 0,0-0,4, 0,4-0,8, and 0,8-1,0. In Figure 5.8, vendors 1 to 6 have been put in positions that translate to their weight points 0,290, 0,806, 0,506, 0,806, 1,000, and 0,670. This resulted in Vendor 1 performing badly, Vendors 3 and 6 performing well, and Vendors 2, 4 and 5 performing excellently based on the AHP-TOPSIS approach. The y-axis describes the positions of the vendors based on the sort of relationship the Boozt should have with the vendors, based on the Figure 5.7. Therefore, Vendors 1 and 5 are transactional, Vendor 3 is collaborative, and Vendors 2, 4 and 6 are strategic. Based on the previously described information, the vendors are put in several segments that include improvement, maintenance, collaboration and prime, as shown in Figure 5.8.

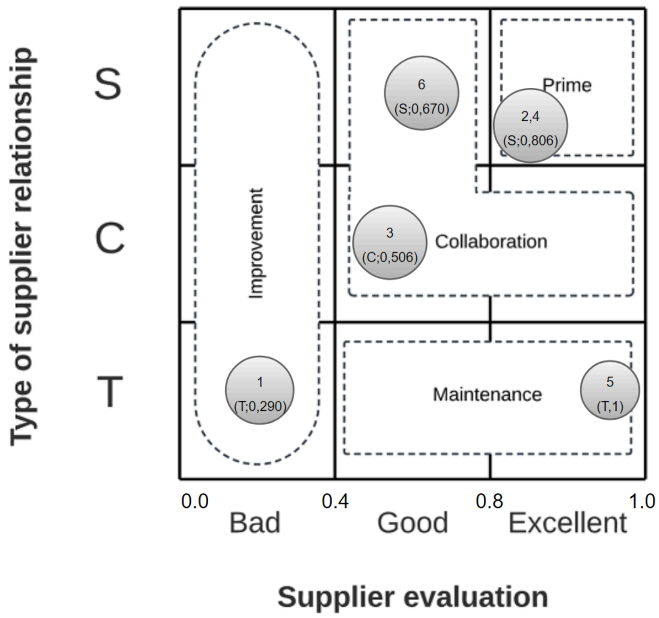

Figure 5.8: The supplier recommendation adapted from Park et al. (2010).

According to Park et al. (2010), these segments suggest how the vendors should be supposedly treated by Boozt in order to improve their relationships and, thus, the supplier performance. Vendor 1 is in the improvement segment, meaning Boozt must be more strict in performing supplier audits, inspections, and improvement activities. Vendor 5 has been put in the maintenance segment, meaning that the current relationship between Vendor 5 and Boozt does not require change; therefore, the relationship continues as it is now. Vendors 3 and 6 are put in the collaboration segment, which will require the presence of improvement in the current cooperation to increase the mutual benefits between the organisation and the suppliers. Finally, Vendors 2 and 4 are put in the prime segment where a long-term relationship with trust should be constructed by Boozt, and the vendors should be provided with strong incentives to stay.

Therefore, the recommendations for Boozt regarding their vendors would be that vendor 1 should be treated more strictly in terms of performing supplier audits, inspections and activities. Vendor 5 does not require change, and continuing the relationship as it is now would be advised. Vendors 3 and 6 require more improvement of the current cooperation to improve the mutual benefits between Boozt and vendors. Lastly, for vendors 2 and 4 Boozt should construct a long-term relationship with trust and create incentives for these vendors in order to keep these vendors.

6. Conclusion and Final Recommendations

Finally, the conclusion is made, including answering the research questions proposed in Chapter 1. Moreover, based on the analysis and results, recommendations are being made for Boozt to improve its inbound logistics and supplier relationships. Afterwards, the limitations and future research regarding this topic are provided.

6.1 Discussions of the Results

The purpose of this thesis is to develop recommendations for warehouse operations and supply relationships in order to improve inbound logistics performance. It was divided into four research questions to accomplish this purpose and maintain the focus. In order to answer these questions and fulfil the purpose, a case study research approach was chosen while taking in certain aspects of design science research. Furthermore, a detailed literature review delved into the theoretical aspects needed to understand the topic. The next step in the process was an empirical study of the company's current situation, structure, and different processes. Thereafter, an in-depth analysis and recommendations were made. Therefore, this research was done using a combination of the following research methods. Boozt gave context to certain interventions that were done to trigger certain situations, leading to the obtained results, including recommendations. These results ultimately answered the constructed research questions, which will be presented in the following sub-chapters.

6.1.1 Research Question 1

How could goods be received from suppliers and managed at the receiving warehouse depending on item characteristics?

In order to answer research question 1, the answer to research question 2 is required. Boozt's as-is situation clearly shows that the VAS/Sorting process is a bottleneck in their system. In order to reduce this, one approach would be to develop better relationships with suppliers who follow Boozt's requirements more willingly when shipping their goods due to the suppliers valuing the relationships. If the VAS/Sorting process is reduced to the point where it is not a core process in Boozt's inbound processes, it will create a better flow. Two to-be maps were constructed, showing how Boozt could receive their goods if the VAS/Sorting process is not there as a core process. The result of these maps does, in fact, reveal that the flow is better. The to-be VSM shows an improvement in the balance between the different C/T's, the total C/T for the processes until the goods have been putaway is also reduced from 729.15s to 157.75s. Moreover, the to-be swimlane reveals that the removal reduces a lot of handling, double-triple handling, and decision-making for the items that require VAS/Sorting.

Furthermore, the goods that do not directly go to the Autostore will be headed to racks referred to as the refill areas. Comparing the different storage policies in the theory with the different advantages and disadvantages they bring, as well as how Boozt's current situation looks like in terms of warehouse buildings and handling, it is concluded that a class-based storage policy would benefit Boozt the most for their refill putaway efficiency. Following the literature, it is recommended that Boozt should stay between 2-5 classes when dividing the goods. This class-based policy could be based on criteria that Boozt themselves value when deciding on class division; however, a two-criteria matrix is recommended to be used due to the limitations and complications single criteria and multi-criteria classifications bring. One example of a two-criteria matrix that is recommended is an ABC-FSN matrix, as shown in Table 6.1.

Table 6.1: ABC-FSN matrix recommendation.

ABC/FSN Matrix			
	F	S	N
A	AF	AS	AN
B	BF	BS	BN
C	CF	CS	CN

AF = Fast moving items in Group A
BF = Fast moving items in Group B
CF = Fast moving items in Group C
AS = Slow moving items in Group A
BS = Slow moving items in Group B
CS = Slow moving items in Group C
AN = Non-moving items in Group A
BN = Non-moving items in Group B
CN = Non-moving items in Group C

In the example recommendation, the classes are divided into three groups: class 1 is made up of CF, BF, AF, AS, and AN; Class 2 is made up of CS, BS, and BN; and Class 3 is made up of CN. Items that are classed as fast, slow and non-moving shouldn't be categorised based on what the literature of the turnover ratios for those three groups are. Instead, it is advised that Boozt perform its own analysis and make conclusions by comparing the turnover ratios of its own products. Based on that, it should do the fast, slow, and non-moving item turnover ratio cutoffs. Finally, Boozt should adhere to the classical division in the literature for the A, B, and C categories when categorising the goods.

6.1.2 Research Question 2

What does the current situation of Boozt's inbound look like?

In order to describe the current situation of the inbound of Boozt, the warehouse and its areas had to be mapped to get an overview of how the processes would flow through the warehouse. From Figure 4.2, the inbound of Boozt can be divided into several areas where the processes take place. There are four areas that are important for the inbound process, and these have been identified as the inbound area, the sorting/VAS area, the put-away area, and the refill area. The sorting/VAS area is where the goods will be checked because the supplier sent different SKUs or did not sort the goods, therefore, receiving an invoice from Boozt to correct the mistake.

These processes are described in Figure 4.5, including the suppliers, receiving, and put-away processes. When an order is sent to the suppliers by Boozt, it will be processed and sent to the warehouse as soon as possible. Then, the goods will be received at the inbound area, where they will be unloaded, placed and scanned. Based on experience, the operator decides where the goods will go to either AS1/AS2, AS3 or refill. This makes the allocation of the goods random without an automated system that decides which area the goods should go to. If the goods are not properly packed, these will require sorting at the sorting/VAS location and sending an invoice to the supplier. The goods that require VAS will be put in AS1. However, if the goods do not require sorting or VAS, the goods will be sent to either AS1/AS2 or AS3 or refilled, depending on where the operator decides to put the goods. If the goods are sent to AS1/AS2 or AS3, it can still occur that the goods require VAS and will be sent to the sorting/VAS location for control. Otherwise, the operators put the goods in AS1/AS2 or AS3 bins. When the goods are sent to refill, these goods will be put in the refill areas, as seen in Figure 4.5. The operators put these goods in racks or hangers depending on the sort of goods. If one of the Autostores requires a refill, then the operators pick the goods from the refill areas and put these goods into the Autostores, which happens on a daily basis.

As a result, mapping and describing the processes led to an overview of the exact processes present. However, these processes were described and made without any time descriptions. Therefore, a VSM had been created in order to see how much time the processes take on average. Figure 5.1 resulted in the cycle time of the receiving, sorting/VAS, and put-away process being respectively 95,33s, 571,4s and 62,42s. These times combined are the value-added time, which is 729.15s, and the non-value-added time, which is 85.64 hours, including waiting time at the inbound area and the time of standing idle at the sorting/VAS area. To conclude, the average cycle time of the sorting/VAS process has a huge impact on the average time a pallet is being processed by Boozt, therefore making it an obstacle in the inbound process. As a recommendation, Boozt could analyse the sorting and VAS process to make it more efficient and less time-consuming by, for example, approaching the suppliers to sort the goods properly.

6.1.3 Research Question 3

How do the suppliers perform compared to each other for Boozt?

The supplier's performance was based on several criteria using the hybrid AHP-TOPSIS approach. The criteria used to compare the suppliers were decided based on the literature and what Boozt values as valid criteria, which were gathered through interviews. Thus, the criteria decided upon were product data, delivery reliability, communication, responsibility and trust. According to the calculations of the AHP-TOPSIS method, it was concluded that Boozt values the criteria: product data first, delivery reliability second, communication third, responsibility fourth and trust fifth. Moreover, comparing how the vendors perform based on the different criteria resulted in a ranking of the vendors, which can be seen in Table 6.2.

Table 6.2: Final ranking of the vendors.

Vendors	Vendor 5	Vendor 4	Vendor 2	Vendor 6	Vendor 3	Vendor 1
Rank	1	2	3	4	5	5
Performance	1,000	0,806	0,806	0,670	0,506	0,290

Vendor 5 has the best performance among the vendors, where Vendors 4 and 2 are equally performing well, followed by Vendor 6 and Vendors 3 and 1, which are underperforming. It should be mentioned that the value of the different criteria is not in line with the theory but is based on Boozt's values. However, literature mentions that trust is important for a better buyer-supplier relationship and, therefore, should be considered valued higher for Boozt.

In order for the suppliers to achieve a higher rank, the results suggest that Vendors 1 and 3 need to improve their overall performance. To begin with, Vendor 1 should focus mainly on the aspects of product data and delivery reliability, while Vendor 3 has to improve responsibility and product data. Vendor 6 needs to take on much more responsibility, and Vendor 5 could make minor improvements in communication. Lastly, Vendors 4 and 2 can make minor improvements in responsibility and communication.

6.1.4 Research Question 4

What should the relationship look like between Boozt and their Suppliers?

Currently, Boozt's practices are not aligned with the found literature. The relationships recommended between Boozt and its suppliers were based on the supplier evaluation and the type of supplier relationship that should exist between each vendor and Boozt. The results of the AHP-TOPSIS approach led to the conclusion that Vendor 1 performs badly, 3 and 6 perform good, while Vendors 2, 4 and 5 perform excellently. For each vendor, a certain type of relationship is suggested that the vendors should have with Boozt based on the Kraljic matrix and Olsen and Ellrams purchasing portfolio. Together with the supplier evaluation, these frameworks concluded that Vendors 1 and 5 should have a transactional relationship, Vendor 3 a collaborative relationship, and Vendors 2, 4 and 6 should have a strategic relationship with Boozt.

As a result, vendors 1 to 6 could be placed in a certain segment, as shown in Figure 6.1. Vendor 1 is placed in the improvement segment, meaning Boozt must be more strict in performing supplier audits, inspections and improvement activities. Vendor 5 is put in the maintenance segment, which states that Boozt is not required to change the relationship with Vendor 5, therefore continuing the relationship as it is now. Vendors 3 and 6 have been put in the collaboration segment, where this relationship with Boozt requires the presence of an improvement in current cooperation to increase mutual benefits between the organisation and the suppliers. Finally, Vendors 2 and 4 are put in the prime segment that requires Boozt to build a long-term relationship with trust and strong incentives for the vendors to hold on to Boozt as a business partner.

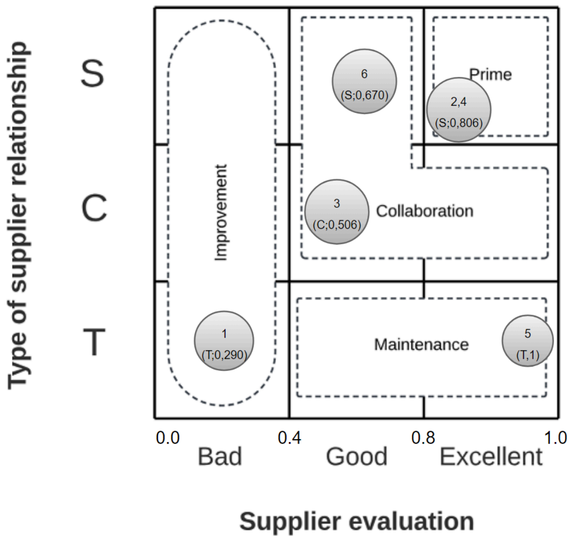

Figure 6.1: The supplier recommendation.

As a recommendation, Boozt should treat the suppliers as described in Figure 6.1, where Vendors 1 and 5 should be treated as transactional, Vendor 3 as collaborative, and Vendors 2, 4 and 6 as strategic relationships. Moreover, Boozt should be stricter with Vendor 1 in performing supplier audits, inspections and improvement activities. Vendors 3 and 6 require the presence of improving current cooperation to increase mutual benefits between Boozt and the suppliers. Finally, Boozt should try to build a long-term relationship based on trust and strong incentives with Vendors 2 and 4. Lastly, the relationship with Vendor 5 should continue as it is now. Altogether, these recommendations should improve the relationships between Boozt and its vendors, leading to better performance in Boozt's inbound process.

6.2 Recommendations

The recommendations that have been given to Boozt have been divided into short and long-term recommendations. The short-term recommendations are recommendations that are believed to be possible to implement within a 6 months period. The first recommendation that fits this time window is to change their refill storage policy from a random to a class-based one and to implement this class-based with a bi-criteria matrix, for instance, an ABC-FSN matrix, while staying within 2-5 classes. The second recommendation would be to start initiating the supplier relationship changes with the suppliers, while also talking to the vendors that are performing worse comparatively to the rest and give pointers to these vendors while having the supplier evaluation results to assist.

Besides the short-term recommendation, a long-term recommendation is made that is believed to be implemented between 6 months to several years. The relationships between Boozt and all its vendors have been treated in the same way. The long-term recommendation would be for Boozt to treat the suppliers differently based on the results of the frameworks. This would mean that Boozt should change its perspective on the vendors and treat the relationship as transactional, collaborative or strategic. These relationships should then be handled in a way that is described by improvement, maintenance, collaboration or prime.

However, building these relationships takes time, especially when the relationships are heading towards collaborative and strategic relationships. Therefore, it is recommended for Boozt to evaluate each of these relationships in order to create an overall better performance for both vendors and Boozt.

6.3 Limitations

Throughout this thesis, various limitations have been identified, the first of which is time constraints. The reason for the time constraint is simply that this is a master thesis with a set time limit, therefore, a more comprehensive study was not possible. For example, due to the time constraint, a full recommendation on where the SKUs would be analysed and classified according to the class-based storage policy was not possible. Additionally, if more time were available it would have been possible to see Boozt apply these recommendations and evaluate their new performance and then compare to prove this study further. Moreover, the limitation regarding the AHP-TOPSIS approach, which is mentioned in the literature, must be considered. The method does not always capture the judgement of the decision-makers accurately.

Furthermore, the weights calculated using the AHP part in the AHP-TOPSIS approach were shown to have a higher consistency ratio than is recommended. Even though it was argued for and accepted, having the inbound team answer more consistently would have been overall better. One approach to counteract this could have been to send out the forms to each member of the inbound team individually, which would have led to more consistent answers from each member. This leads us to another limitation, which is the shortage of answers. It would have resulted in a more accurate result of the AHP-TOPSIS if there were more answers to reduce the bias even further, for example, having answers from other related departments. The final limitation of this study is the measurements done for the design of the VSM. These measurements could have been better if Boozt had this type of data in their system. Another way would have been to directly follow one pallet from the receiving point until it has been fully putaway into the Autostore. However, since the average duration for this is more than 70 hours, it is both not physically possible and very time-consuming. The reason for this is that this process has to be measured several times in order to have an average of the processes.

6.4 Future Research

The research has given many valuable insights regarding supplier evaluation and warehouse operations regarding e-commerce and inbound logistics. However, certain aspects of this research could require further research. The selection of vendors and respondents for the AHP-TOPSIS approach was quite small. Therefore, it could be valuable to research the supplier evaluation on a larger scale and the possibility of comparing the supplier evaluation between e-commerce companies. The reason for a larger scale of respondents is to make the research more valid by counteracting the high consistency ratio achieved when performing the AHP-TOPSIS approach during this research. This could include assessing how suppliers would be approached by the companies where suppliers are asked to perform better in certain areas and what kind of incentives are required. Moreover, an opportunity would be to research the criteria different companies in the e-commerce sector find important, as these are used for supplier evaluation.

Besides the supplier's evaluation, the warehouse's SKU problem requires future research. It would be interesting to apply the suggested ABC-FSN analysis for an e-commerce company where many SKUs are present that have to be handled. This has not been done within this research due to time constraints, making it an interesting future research topic for an e-commerce company like Boozt or any other. Moreover, this research includes only the fashion items and not the bulky items being handled in the warehouses of Helsingborg. Combining bulky and fashion items could be valuable for research in e-commerce and warehouses, as well as how effectively these could be handled and how to consolidate them. It makes it interesting as well how these goods will be sent from the supplier to the warehouse and from the warehouse to the customer efficiently. Overall, inbound logistics and e-commerce, as combined research, are not often researched and found within the literature, making it a relevant and important topic to research these days due to the growth of e-commerce and its digitalisation. While this thesis has contributed to the research, there remains a need for further research in this area.

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Appendices

Appendix A - Interview Guide

<u>Interview questions with Logistics Project Manager & Production Manager Inbound of Boozt</u>

1. Receiving Process:
   - How does the warehouse handle the receipt of incoming shipments?
   - What steps are involved in the receiving process from the moment a shipment arrives at the warehouse?
   - Are there any specific protocols for verifying the accuracy and condition of incoming goods?
   - What are the exact steps, starting at the supplier until it is placed in the warehouse?
   - Warehouse location principle: Random, Zone, or Fixed – or are perhaps all of them used, but for specific items, i.e., a differentiated approach?

2. Dock Operations:
   - Can you describe the operations at the receiving docks?
   - How are trucks unloaded and goods transferred into the warehouse?
   - Are there any strategies to optimize dock efficiency and minimize wait times for incoming shipments?
   - Does the company use cross-docking?

3. Inventory Management:
   - How quickly are incoming goods made available for storage or distribution within the warehouse?
   - How do you handle over or understock situations?
   - What systems or software do you use to track incoming shipments?
   - How good is your data quality (i.e., the quantity on the shelf versus the quantity in the computer-based system)?
   - What principle and how often are inventory counted: Cycle counting (a few items every week), annually (set off 1 or 2 days for counting the inventory), or do you do another approach?

4. Supplier Relations:
   - How does the warehouse communicate with suppliers regarding inbound shipments?
   - Are there any initiatives or partnerships in place other than the scheduling tool to improve collaboration with suppliers and streamline inbound logistics processes?
   - How does the warehouse handle issues such as late deliveries or discrepancies in incoming shipments?
   - How are the relationships with the suppliers and are these being maintained? Is there a loyalty reward to suppliers, or when they perform well within the supply chain?
   - What are the current Incoterms with the suppliers, who is responsible/pays for what?

5. Continuous Improvement in Inbound Logistics:

- How do the inbound logistic operations seek to improve efficiency and effectiveness?
- Are there any recent initiatives or improvements made to enhance inbound logistics processes?
- What feedback mechanisms are in place to gather input from staff or stakeholders regarding inbound logistics operations?

Interview questions with the Supply Chain Director of Boozt

1. Can you describe your job role, what does it contain and what are the goals to achieve as boozt's supply chain director?

2. How much connection do you have here in Malmö with the processes in Ängelholm?

3. Can you share your perspective on the current state of Boozt's inbound processes and any key areas you believe require immediate attention or improvement?

4. What are the current Incoterms with the suppliers, who is responsible/pays for what?

5. Is there a supplier list regarding Boozt's suppliers, and who are the biggest suppliers? Best seller, hugo boss, adidas, tommy hilfiger,

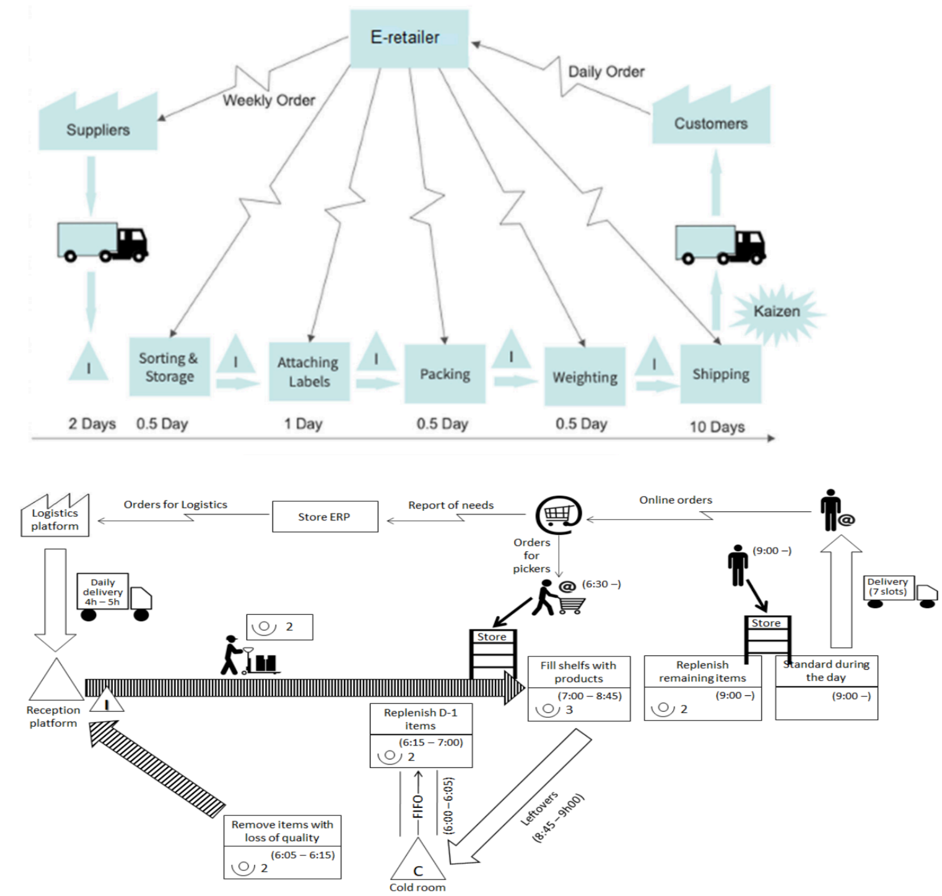
6. How do you currently measure the performance of the suppliers? KPI'S if so which ones?

7. How do you currently measure the performance of the inbound logistics? Does this measure of performance start once suppliers ship their goods until put-away at the warehouse or are the moments of measuring performance differently?

8. What is currently the strategy and relationship for the different suppliers, are they all transactional or do you have long-term goals with them?

9. Do you collaborate with the suppliers, for example, are there any incentives for them if they do well, or do you do supplier audits?

10. We are planning on doing a value stream map on the inbound processes from receiving up to the putaway of Boozt. Would it be possible to receive an average number for the products/SKUs lead time for the different processes. (Maybe one for the popular products and one for the less popular ones) or by preference of Boozt.



Pictures for reference of the value stream map during interview

11. We were planning to do a ranking for your current suppliers, however, we need some values from your opinion. First of all, which criteria does Boozt value from the suppliers, such as price, quality, trust, delivery reliability, reputation, production capacity, communication, cooperation. responsibility, product data. These criteria are not restricted, so if there are other criteria than these that Boozt values, we would like to know.

12. How would these criteria rank compared to each other on a scale from 1-9 where 9 is extremely preferred and 1 is equally preferred? For example if price is extremely preferred over quality then price would be given a “9”.

13. Out of the main suppliers how would you rate them to each other in these different criteria with the same 1-9 scale?

Interview questions with the Buying Director of Boozt

1. Can you describe your job role, what does it contain and what are the goals to achieve as Boozt's Buying Director?

2. How much connection do you have here in Malmö with the processes in Ängelholm?

3. How do you currently rate your suppliers?

4. Is there a supplier list regarding Boozt's suppliers, and who are the biggest 5-7 suppliers?

5. Is Boozt usually one of your supplier's biggest customer or among the biggest customers?

6. If you feel Boozt is not getting prioritised the way they should be at a supplier how does this get handled in order to ensure some form of priority?

7. What is currently the strategy and relationship for the different suppliers, are they all transactional or do you have long-term goals with them?

8. Do you collaborate with the suppliers, for example, are there any incentives for them if they do well?

We are planning on doing a supplier evaluation comparing your biggest suppliers and would like your opinion on the different criteria. We are thinking of sending out an Excel sheet to you that will look somewhat like this as well as the definitions included to the terms, is this something you could fill in and send back?

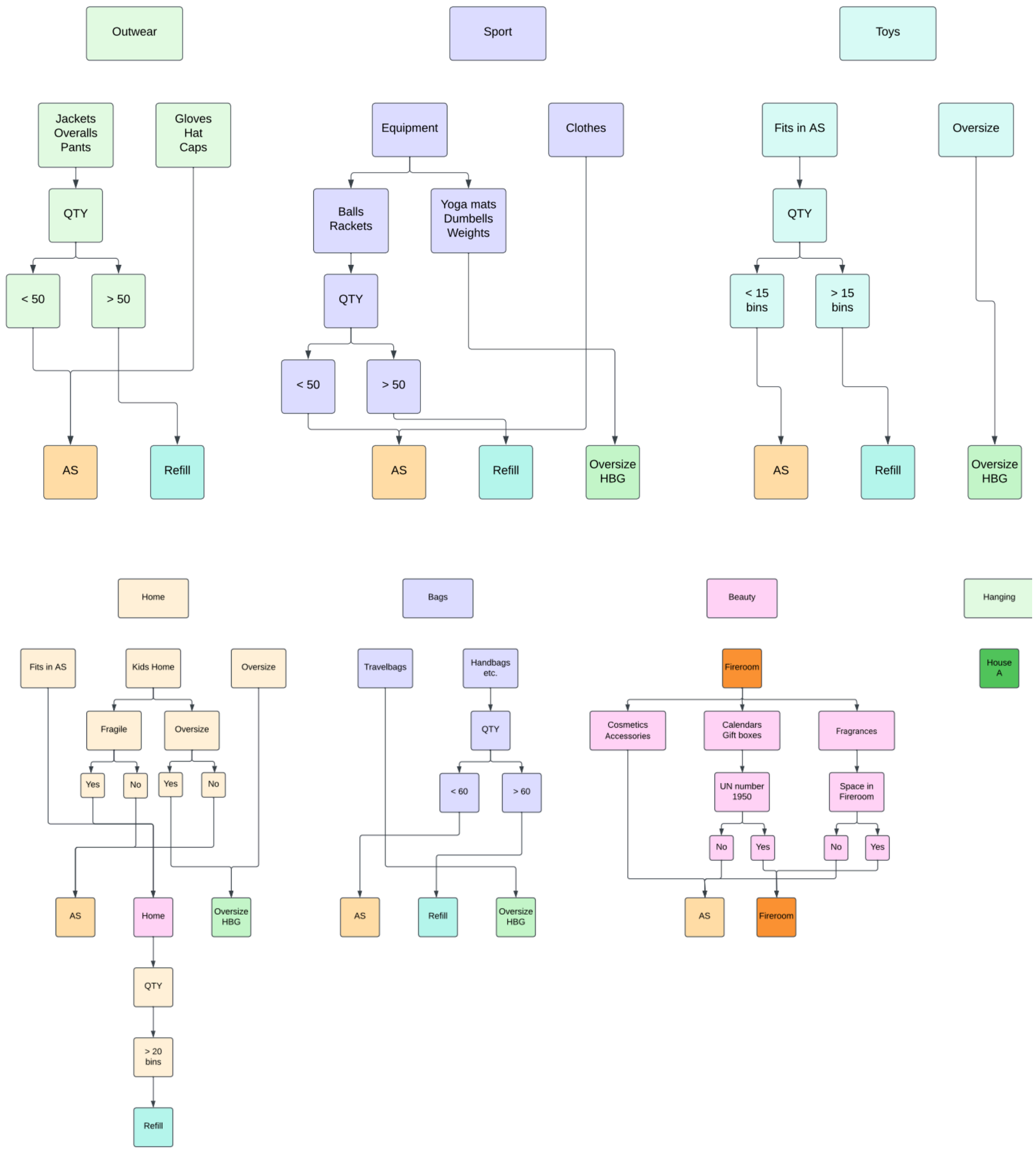
Vendors compared to each other with regards to X																		
									Equal									
Supplier 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 2
Supplier 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 3
Supplier 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 4
Supplier 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 5
Supplier 1	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 6
Supplier 2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 3
Supplier 2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 4
Supplier 2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 5
Supplier 2	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 6
Supplier 3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 4
Supplier 3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 5
Supplier 3	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 6
Supplier 4	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 5
Supplier 4	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 6
Supplier 5	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supplier 6

Email question to the Chief Technology Officer of Boozt

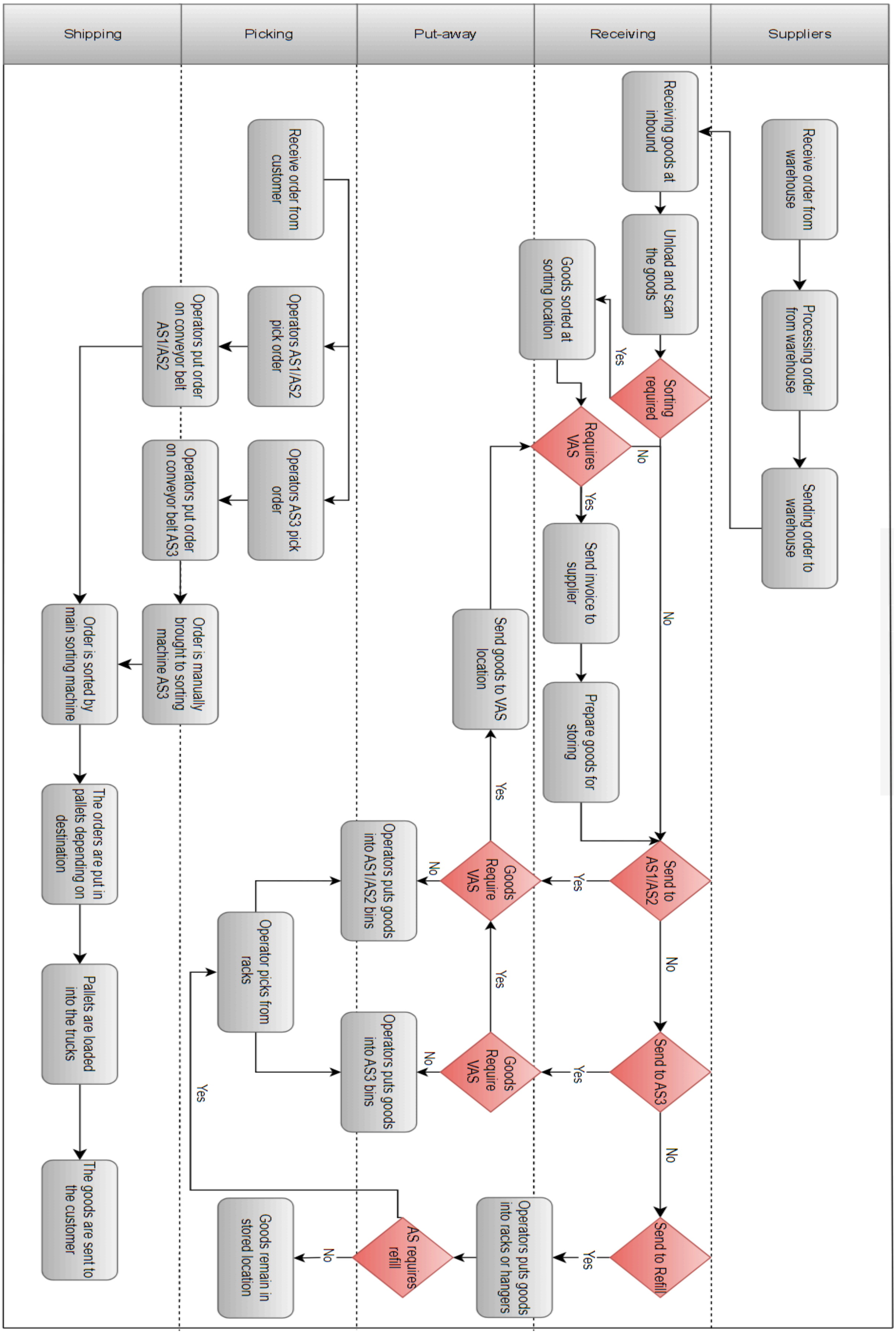
Can you provide a short written description/overview of what the problems/bottlenecks are of the inbound logistics from your point of view?

Appendix B - Company Information

Sorting Logic



The As-Is Swimlane Map of the Warehouse Operations



Appendix C - Form for Supplier Evaluation

<u>Instructions of the form</u>

Instructions

Start Here

1. On the next sheet, you will rank companies based on a number of criteria. These criteria are defined below.
2. The ranking system is explained in further detail below.

Criteria Definitions

Trust:	Sharing ideas, technology where its not in a self-serving way while maintaining mutal respect, honesty and transparency.
Delivery reliability:	The ratio of the number of deliveries made without any error regarding time and quantity to the number of deliveries in a contract.
Responsibility:	Taking responsibility means acknowledging and accepting accountability for one's actions, decisions, and their consequences, whether positive or negative.
Communication:	How well and responsive are the suppliers communicating towards Boozt when necessary.
Product data:	How well the supplier performs on adding product data to their delivieries.

Ranking System: The meaning of the numerical values in the pair wise comparisons

This table can also be seen in the "Fill In" sheet to reduce the need of going back and forth between the sheets

Preference or Judgment	Numerical Value
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

Ranking Example: Highlight only ONE number in each row. For example, if delivery reliability is strongly preffered over trust then highlight the number 5 with the green color on the side of delivery reliability, where it is on the same row as trust. However if trust is strongly preferred over delivery reliability then highlight the number 5 on the side of trust.

In the figure below an example is done where:

Row 1: Delivery reliability is strongly preferred over trust

Row 2: Trust is extremely preferred over communication

Criterias compared to eachother

									Equal									
Trust	9	8	7	6	5	4	3	2	1	2	3	4		6	7	8	9	Delivery reliability
Trust		8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Communication
Trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Responsibility
Trust	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product data
Delivery reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Communication
Delivery reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Responsibility
Delivery reliability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product data
Communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Responsibility
Communication	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product data
Responsibility	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product data