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Streamlining the Ordering Process

A Case Study of Alfa Laval

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Date: 11/6 2021

Acknowledgment

This master's thesis has been conducted during the spring semester of 2021 at the department of Engineering Logistics at the Faculty of Engineering at Lund University. The thesis encompasses 30 credits and concludes the master's program in Industrial Engineering and Management. It has been conducted at Alfa Laval under the mentorship of Louise Bildsten.

The authors would like to thank everyone involved in making this thesis possible. Thanks to our supervisor Louise Bildsten at LTH that during the course of the thesis provided guidance and kept the work on track. Further, thanks to Katia Lindgren, our contact and supervisor at Alfa Laval, for your engagement, trust, inputs, and your help in gathering information and data. Finally, a big thank you is directed to all the employees at Alfa Laval who have been involved in the thesis in any way. You have been very welcoming and helpful; without you this thesis would not have been possible to conduct.

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Lund, 11/6 2021

Abstract

Title - Streamlining the Ordering Process - A Case Study of Alfa Laval

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Background - One of Alfa Laval's factories in Lund, LA, has noticed that up to 50% of all order proposals suggested by their ERP system JEEVES is considered to be irrelevant and are subsequently disregarded by the purchasers. Consequently, many purchasers disregard the parameters in JEEVES that control what proposals get suggested and instead order on "gut-feeling" and personal experience. Not only does this create problems because of a lack of objective parameters, but it is also a waste of purchasers' time to go through and disregard proposals every day. Alfa Laval has therefore expressed an interest in increasing the accuracy and reliability of the proposals suggested by JEEVES, as well as decreasing the time of the order proposal process.

Purpose - The purpose of this thesis is to evaluate Alfa Laval's ordering process in order to increase the reliability and accuracy of the order proposals, as well as reduce the amount of time spent handling said order proposals.

Research Questions -

- How is the current order proposal process organized?
- How can order parameters be improved to increase their reliability and accuracy, and decrease order proposal handling time?
- How can items be categorized to increase the reliability of order proposals?

Method - This thesis uses a case study approach with an explanatory research purpose, as the penultimate goal is to evaluate and improve the ordering process at Alfa Laval. Furthermore, a combination of qualitative and quantitative data was used in order to gather a comprehensive view of the current processes and order parameters at Alfa Laval.

Findings - Many of the parameters in JEEVES are inaccurate due to negligence and because they have not been updated since their introduction. Suggestions for improving said parameters are provided, and implications discussed. Moreover, it is proposed that Alfa Laval should divide their items into three different categories and employ different approaches for each category. The combination of these two proposed improvements means that Alfa Laval will increase the accuracy and reliability of their proposal parameters as well as reduce the number of proposals and overall time spent on handling order proposals.

Keywords - *Ordering Process, Item Classification, Inventory Management, Alfa Laval, JEEVES*

Table of Contents

List of Figures

List of Tables

List of Abbreviations

CDV	*Coefficient of Demand Variation*
DDLT	*Demand During Lead Time*
DILO	*Day in the Life of*
EOQ	*Economic Order Quantity*
ERP	*Enterprise Resource Planning*
FC	*Forecast*
GCC	*Global Core Components*
IDS	*KPI: Inventory Days of Supply*
KPI	*Key Performance Indicator*
LA	*Lund Assembly*
LTL	*Lead Time Limit*
MAD	*Mean Average Deviation*
MOQ	*Minimal Order Quantity*
MRP	*Material Requirements Planning*
MTO	*Make-to-order*
MTS	*Make-to-stock*
NPD	*New Product Development*
NVA	*Non-Value Added*
OFLTd	*KPI: Order Fulfillment Lead Time Discrepancy*
OP F&E	*KPI: Operating Factory & Engineering Result*
OSL	*Optimal Stock Level*
Repl_ALL	*All Replenishments*
Repl_LTL	*Replenishments within Lead Time Limit*
RES_LTL	*Reservations within Lead Time Limit*
ROP	*Reorder Point*
ROT	*Run Out Time*
SL	*Service Level*
SS	*Safety Stock*
SWOT	*Strengths, Weaknesses, Opportunities & Threats*

1 Introduction

In the introduction chapter, the reader will be acquainted with the background of purchasing, Alfa Laval, as well as how purchasing works at Alfa Laval. The authors will also present the problem faced by Alfa Laval, the purpose of the thesis and the research questions that will be answered.

1.1 Background

Purchasing has in recent years received an increased amount of academic interest, resulting in an increased number of articles on the topic, and it has been widely accepted as a key driver for competitive advantage (van Weele, 2018). The large amount of money, commonly around half of a company's sales turnover and sometimes up to 80 % of total costs (Olhager, 2019), related to the purchase of production materials, investment goods, and services in industrial companies implies that purchasing decision-making heavily affects their bottom-line.

In addition to affecting purchasing costs, the purchasing department can also influence the amount of tied-up capital in operations, both by reducing the cost per item and by planning purchases effectively and efficiently. It is also important to consider long-term performance through strategic purchasing, and challenge suppliers to align them with the company's business strategy and improve their performance (van Weele, 2018).

Purchasing not only affects the bottom line but also plays a key role in the company's value chain through securing material supply in time, at the right quality and quantity while maintaining low total costs. Within Porter's (1985) definition of a value chain, van Weele (2018) states that purchasing should support operations management, and inbound and outbound logistics, and be based on forecasts or customer orders depending on the manufacturing strategy of the company as seen in Figure 1.1.

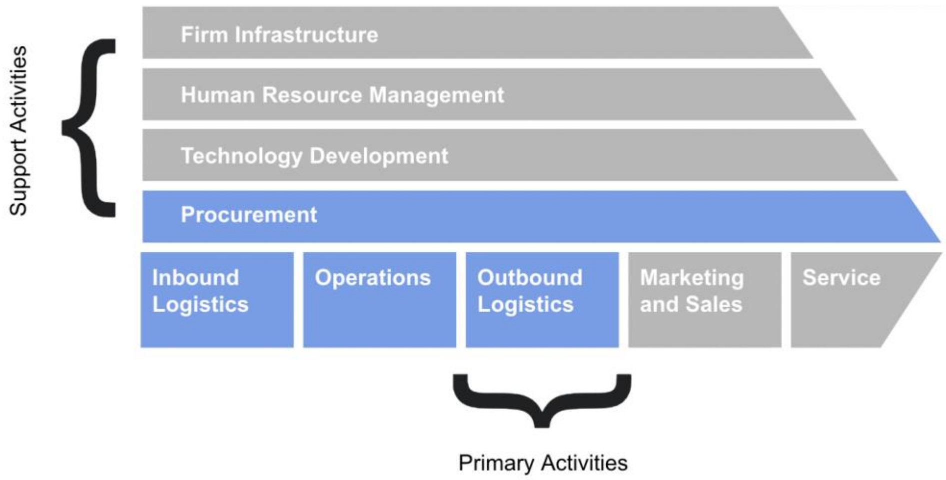


Figure 1.1: Porter's value chain, with procurement and activities it should support highlighted. Adapted from Porter (1985), with input from van Weele (2018).

The ordering process is the part of the purchasing process where orders are placed. Van Weele (2018) states that the main way management can improve ordering is by establishing proper order routines. This thesis will focus on the ordering process within purchasing at Alfa Laval and aims to streamline the process in order to save time and create a more unified process.

1.1.1 Alfa Laval

Alfa Laval was founded in 1883 by Gustaf de Laval and is currently the world leader in three technologies, heat transfer, separation, and fluid handling. Alfa Laval's largest segment is currently heat transfer, but it was with the separation technology that the company was founded. Alfa Laval's market share in the different categories can be seen in Table 1.1 (Alfa Laval, 2019).

Table 1.1: Alfa Laval's share of the market within their key technologies (Alfa Laval, 2019).

Technology	Market Position	Market Share	Percentage of Total Sales
Heat Transfer	1	>30%	40%
Separation	1	25-30%	17%
Fluid Handling	1	10-12%	22%

Alfa Laval sells products that are used in a large variety of industries, and they reach their customers through three separate sales divisions: Energy, Food & Water, and Marine. Alfa Laval's goal is to optimize customer processes to benefit the people and the environment. They do this by investing heavily in innovations, around 2.5% of total sales, and by holding over 3700 patents. (Alfa Laval, 2019) Through the three dimensions of their purpose: *putting our customer first*, *empowering our people*, and *making our world better*, *every day* they aim to continue the growth they have had for the last few years (Alfa Laval, 2021)

1.1.2 Purchasing at Alfa Laval

Each factory in Alfa Laval has its own purchasing department which handles purchases for that specific factory. Therefore, the purchasing structure is considered to be decentralized. Alfa Laval in Lund consists of two different factories, Lund Assembly (LA) and Global Core Components (GCC). Purchasing is split into two different departments, GCC Source and LA Source. GCC Source is focused on purchasing raw materials for plates and gaskets for use in the GCC factory, while LA Source purchases items such as frames, pressure plates, etc. Items purchased, and built, by both departments are then combined into different products, such as heat exchangers, in LA Make. The structure of the purchasing department at the Lund site is visualized in Figure 1.2.

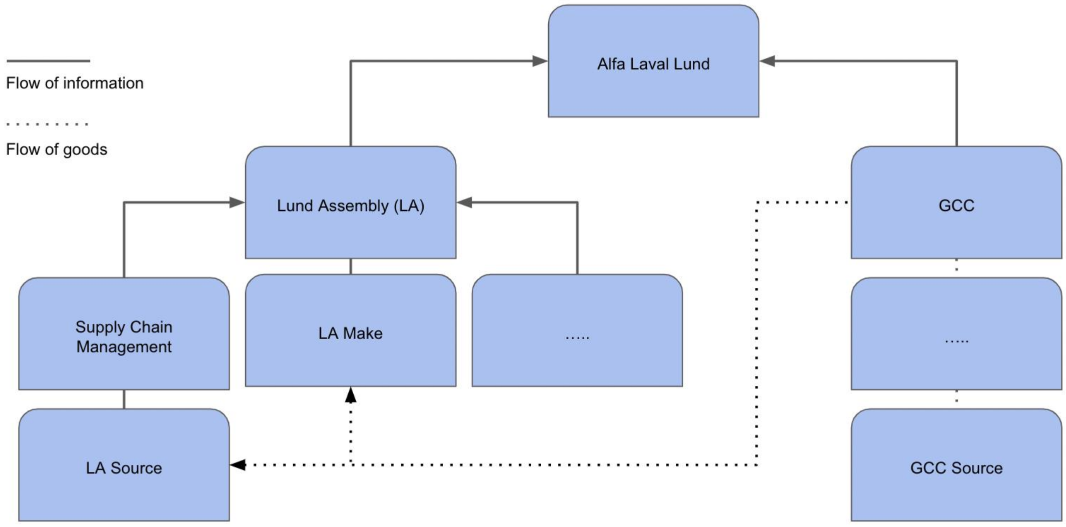


Figure 1.2: Purchasing structure of Alfa Laval in Lund.

1.2 Problem Description

At LA, they are currently experiencing a problem with purchasers receiving a large number of order proposals that are not relevant. According to Alfa Laval, the number of proposals ignored is upwards of 50% of the total amount of proposals created by the system. The cause of this is currently unclear, but Alfa Laval suggest that it is connected to the parameters that controls what proposal is suggested, and when it is proposed. Alfa Laval further sees potential in classifying their inventory in more accurate way, and utilize the resulting categories in the ordering process.

This leads to a waste of purchasers' time and a decrease of trust towards the system in general. Furthermore, it also leads to purchasers basing the decision of whether or not to buy on experience rather than on data and objective parameters. This can risk a sort of maverick buying, which is when purchasers act on their own without the support of the organization, and human error. Moreover, Alfa Laval suspects this is a cause for understocking and/or overstocking, leading to extra costs.

1.2.1 Purpose and Research Questions

The purpose of this thesis is to evaluate Alfa Laval's ordering process in order to increase the reliability and accuracy of the order proposals, as well as reduce the amount of time spent handling said order proposals. To fulfill this purpose, the following research questions have been formed as a guide for the thesis:

RQ1: How is the current order proposal process organized, and what issues are there within the process?

RQ1 is formed in order to understand the order proposal further and identify any issues that need addressing. Both qualitative and quantitative issues are considered.

RQ2: How can order parameters be improved to increase their reliability and accuracy, and decrease order proposal handling time?

The parameters used in creating order proposals are handled in RQ2, where each parameter will be analyzed with the intention of bettering the order proposal process.

RQ3: How can items be categorized to increase the reliability and accuracy of order proposals?

Some items have characteristics that lend themselves well to less manual handling. By categorizing items, an easy procedure for purchasers to determine which items can be handled less manually can be created.

1.2.2 Scope and Limitations

While Alfa Laval is an international company with many different products, articles, and factories, this thesis will focus on one of the factories in Lund, LA. The analysis will involve the operational part of the purchasing process, focusing on the ordering process. Only items that are classified as standard will be handled in this thesis. That means that items that are classified as New Product Development (NPD) products, items that are produced at LA Source, and items that are anything other than Straight Rebuy items will not be considered.

Regarding the parameters that will be analyzed in the thesis, the authors have decided that the inventory carrying cost is out of scope as this is a strategic number set by management and something that is difficult to change. Furthermore, the methods used by JEEVES and Alfa Laval to forecast will not be analyzed to a great extent as this is something that could be considered a separate thesis in itself. Lastly, due to time constraints, only an estimation of how much time can be saved by the proposed implementations and changes will be provided.

2 Methodology

The following chapter aims to explain the methodology used throughout the thesis. Various choices made regarding which type of methodology and approach to use in the thesis are also discussed.

2.1 Research Purpose

According to Yin (2018), there are three main purposes that research can be designed to fulfill: exploratory, descriptive, or explanatory. Saunders, Lewis and Thornhill (2016) expands on Yin's purposes and adds a fourth, evaluative. A study can also consist of a combination of these purposes, to best fit the issue at hand, and the distinction between purposes is not always clear (Yin, 2018).

An exploratory study asks open-ended questions and aims to discover more about a phenomenon and gain insights into what is happening. It often starts with a broad focus that becomes narrower as the understanding of the problem deepens. A descriptive study aims to describe a phenomenon accurately, to deepen the understanding. An explanatory study explains causal relationships between variables by studying a phenomenon. This can be done using either qualitative data or quantitative data, commonly with the help of statistical tests. Finally, an evaluative study seeks to evaluate how effective a strategy, policy, or process is (Saunders et al., 2009; Yin, 2018).

This thesis will mainly be conducted as an explanatory study, as the ultimate goal is to evaluate and improve the ordering process at Alfa Laval, by explaining the relationship between variables in the ordering process. Initially, to gain a deeper understanding of the phenomenon, a more exploratory approach will be used, especially during the mapping of the ordering process.

2.2 Research Strategy

According to Höst, Regnell, and Runeson (2011) there are four different research strategies, these are Survey, Case Study, Experiment, and Action Research, as described in Table 2.1.

Table 2.1: : The different strategies as described by Höst et al (2011).

Strategy	Purpose
Survey	To describe an event or phenomena by using a questionnaire. It is primary used as an descriptive method.
Case Study	To describe a problem in-depth. Is especially applicable to organizations to understand how to improve their processes. It is primary used as an exploratory method.
Experiment	To find cause-effect links and to explain how and why different phenomena happen. It is primarily used as an explanatory method.
Action Research	To improve something, be that a process or product, at the same time as studying said object. It is primarily used as with an objective of improving something.

With the purposes described above, this thesis will be conducted as a case study, as its purpose is to describe a problem at a company in-depth to improve one of their processes. Moreover, Voss, Tsikriktsis, and Frohlich (2002) means that a case study is appropriate when three conditions are fulfilled:

- The research questions should be of nature “how” or “why”.
- The strategy should not require control over behavioral events.
- The study should focus on contemporary events.

As all of the three conditions are met in the case of this thesis, choosing a case study as the research strategy is preferred. The case study will be described in more detail below.

2.2.1 Case Study as a Research Strategy

As Yin (2018) states, a case study is an empirical inquiry that explores a contemporary issue within its specific context. Yin (2018) further expands on this and mentions that case studies are especially useful when the boundaries between the issue and the context are blurred. Further, case studies are also appropriate when describing and investigating a problem in-depth within the real world and it works well when there are more variables than just data points and benefits from prior development in theory (Yin, 2018). Voss et al. (2002) further mean that a case study can be chosen when the purpose of the research is either exploration, theory building, theory testing, or theory extending/refining. However, Scholz and Titje (2001) is of the opinion that case studies are viewed with a certain amount of distrust in certain disciplines where they are seen as “bad research” and “without design”. Saunders et al. (2016) expands on this by saying that they are distrusted because the idea that they cannot produce generalizable and reliable results . However, this opinion is slowly going away and the view of the case study as an asset is gaining ground (Saunders et al., 2016).

A case study can be broken down into two main categories, single case studies and multiple case studies, where either a single or multiple entity or organization are analyzed (Yin, 2018). Both Yin (2018) and Scholz and Tietje (2001) agrees that these can further be broken down into single or multiple case studies with either a holistic view or with an embedded unit of analysis. Yin (2018) specifies that with holistic designs, the unit of analysis is confined to a single level within the case, while an embedded design is concerned with several sub-units within the originally defined case. Moreover, an embedded case analysis is preferred when the analysis is a combination of qualitative and quantitative (Scholz & Tietje, 2001). However, Yin (2018) emphasizes that it is important that the embedded units of analysis are within the original case study.

Yin (2018) is of the opinion that all the above-described types of case studies can lead to a successful case study, however, when the choice and resources exist, multiple case studies are often preferred over single case studies. Voss et. al (2002) agrees with this, and further mean that a disadvantage with single cases is that it limits the generalizability of the study but also that it increases the risk of biases since only a single entity or organization is represented. However, they also emphasize that with a single case study it is easier to analyze a problem in-depth than it is with a multiple case study. The risk with a multiple case study is that you get a very surface-level analysis (Voss et al., 2002).

2.2.2 Selecting Type of Case Study

When deciding what type of case study to perform, Yin (2018) means it is important to understand if the study aims to tackle a broader subject, the holistic approach, or an issue that can be broken down into smaller components, the embedded unit of analysis approach. According to Yin (2018), a holistic view is useful when there are no sub-units within the case. A problem with this is that the case study runs the risk of being too broad, abstract and the research question may change during the work or the focus shift. However, Yin (2018) says that a way around this is to have the embedded units of analysis. But, with this approach, the case study runs the risk of only delivering on the sub-units and not on the larger issue at hand, which is something that needs to be considered (Yin, 2018).

To decide whether to do a single- or multiple-case study, Yin (2018) proposes 5 rationales or circumstances. These five rationales are explained in Table 2.2.

Table 2.2: The five rationales suggested by Yin (2018).

Rational	Description
Crucial	The case is critical to the proposed theory.
Unusual	The case deviates from ordinary norms.
Common	The aim is to capture the circumstances of an everyday situation or process.
Revelatory	When a case has previously been inaccessible to the public.
Longitudinal	When the same case can be studied at two different points in time.

This thesis fulfills the rationale of a common case study, as the objective of the thesis is to evaluate and analyze an everyday situation at the purchasing department at Alfa Laval. Furthermore, the case will use an embedded unit of analysis which will be described in the next chapter. Therefore, this case will be conducted as a single case study with embedded units of analysis. The unit of analysis will be further explained in section 2.3.1.

2.3 Research Design

According to Höst and Runeson (2009), there are five steps involved in conducting a case study, these are summarized in Table 2.3.

Table 2.3: different steps in the case study according to Höst and Runeson.

Step	Process	Purpose
1	Designing the case study	What is the study about and what are the objectives and limitation?
2	Preparation for data collection	What kind of data do we need to collect and how will we collect it?
3	Collecting data	Collect the data
4	Analysis of the data	Analyze the data
5	Reporting	What did the case study find?

By using the process steps suggested by Höst and Runeson in Table 2.3, a research process or investigative framework of defining, collecting and analyzing the issue at hand was created as seen in Figure 2.1.

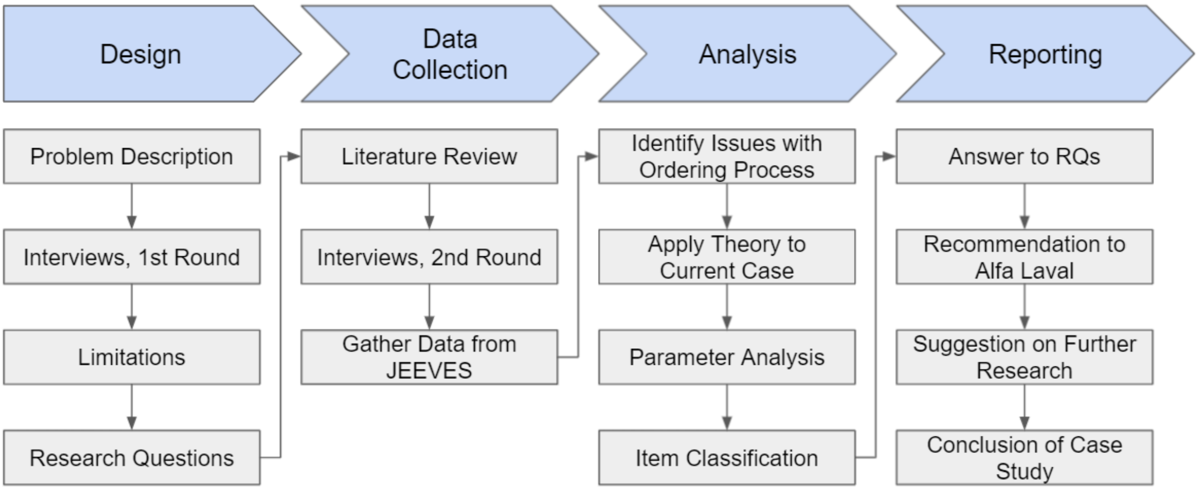


Figure 2.1: The investigative framework applied to the case study.

In Figure 2.2, the *Design* step is referring to Chapter 1 and 2, *Data Collection* is referring to Chapter 3 and 4, *Analysis* refers to Chapter 5 and *Reporting* refers to Chapter 6. What each step in the framework is connected to is summarized in Table 2.4.

Table 2.4: The different steps in the framework and the chapter they are connected to.

Step	Chapter Number	Chapter Name
Design	1 & 2	Introduction & Methodology
Data Collection	3 & 4	Theory & Empirical Data
Analysis	5	Analysis
Reporting	6	Conclusion

2.3.1 Unit of Analysis

The Unit of Analysis refers to the actual thing or entity that is being studied (Yurdusev, 1993). The unit of analysis can be focused on different things from certain, individual words being used in a text to characteristics of people being involved in a study or an analysis of images (Saunders et al., 2016). In this thesis, the Unit of Analysis is therefore the ordering process at Alfa Laval, and related activities. This thesis will also include embedded units of analysis, these are the different aspects of the ordering process that will be looked at, i.e., parameters and item classifications as shown in Figure 2.2.

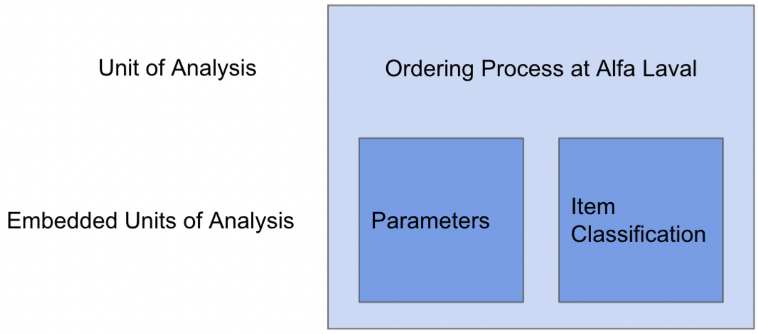


Figure 2.2: The unit of analysis and the embedded units of analysis.

2.4 Data Gathering

This section will elaborate on what kind of data will be used in the thesis, and what methods will be used for gathering said data for the purposes of this thesis.

2.4.1 Primary and Secondary Data

Collected data can be divided into two subcategories: primary and secondary data. Primary data refers to data that was collected by the researcher, while secondary data is data that was collected by a third party. (Bell et al., 2015)

This thesis uses a combination of primary and secondary data. Primary data is collected through interviews, data extraction from the ERP-system JEEVES, and from observations. Secondary data is collected in the literature review, to be used as a basis for creating models and reviewing parameters in JEEVES.

2.4.2 Combining Qualitative and Quantitative Research

Broadly speaking, there are two types of data: qualitative and quantitative. When using qualitative data, often called soft data, the results are often in words, descriptions, or images which makes it more complex and harder to handle. Quantitative data, often called hard data, concerns data that is more easily measurable, i.e., weight, color, length, etc., making it easier to handle larger amounts. The methods used to process these different kinds of data are also different; while qualitative data requires sorting and categorization, quantitative data can be analyzed using statistical tools such as Excel or SPSS (Höst et al., 2011).

These differences do not make the two types of data incompatible with each other. In fact, Bell et al. (2015) state that it is not only possible but desirable to use a combination of the two data types in some cases. Furthermore, Höst et al. (2011) mean that in complex situations, where people and their choices are involved, a combination of the two data types is desirable. Therefore, since the problem that is studied in this thesis regards both hard and soft aspects, a combination of qualitative and quantitative data will be used.

2.4.3 Literature Review

A literature review is a search for relevant academic information on a topic with the purpose of understanding what is already known about the topic and examining relevant concepts and theories (Bell et al., 2015).

Rowley and Slack (2004) mention four strategies for conducting a literature review:

- Citation Pearl Growing: Start from one or a few documents and develop keywords from these to search for other sources.
- Briefsearch: Gather a few documents for gaining a quick starting point for future work.
- Building Blocks: A thorough search is performed by extending concepts and searching for synonyms, creating an exhaustive list of documents.
- Successive Fractions: Refers to searching within an already existing document to reduce a too large set of documents.

The literature review in this thesis will use citation pearl growing, and start with broad procurement literature to identify relevant keywords. A search for relevant articles, journals, and books will be performed using the following databases:

- LUBsearch
- Google Scholar
- Web of Science

To research similar theses on the subject, the following databases will be used:

- DiVa
- LUStudentPublications

As search engines have improved over the years, simple searches with keywords can go a long way (Rowley and Slack, 2004). To ensure that the literature review will be thorough and consistent, the following identified keywords will be used in all databases:

- Order selection
- Order proposals
- Ordering process
- Purchasing policy
- Purchasing process
- Ordering process
- Inventory management

The findings from the literature review will be used as a basis for the theory chapter since this thesis uses an abductive research method and draws from literature to find solutions for the problems at hand in an iterative manner.

2.4.4 Interviews

Saunders et al. (2016) state that there are three main types of interviews: structured interviews, semi-structured interviews, and unstructured interviews. Structured interviews are based on standardized questionnaires and gather quantitative data as the questions are identical. In semi-structured interviews, a list of themes to discuss is used, but the interview is adapted to the flow of the conversation. Finally, unstructured interviews are informal and give the interviewee the opportunity to talk freely. Semi-structured and unstructured interviews both gather qualitative data as the questions are not standardized.

Two rounds of interviews will be conducted during this thesis, each round using the interview type appropriate for the purpose of the interview. The initial round of interviews will be conducted as unstructured interviews, with the aim of exploring the problem, the company, and gathering information for use in mapping the processes. Multiple interviews will be conducted in order to get input from various stakeholders. The second round of interviews will be semi-structured, as the purpose is to gain an understanding of various parameters used in the current ordering process. The data gathered during the second round of interviews will complement data gathered in the initial round of interviews and data from observations, which is why a semi-structured approach is preferable. A summary of the interviews that will be performed can be found in Table 2.5 and the interview guides used can be found in the Appendix.

Table 2.5: Summary of interviews and interview types.

	Initial Round	**Second Round**
Structure	Unstructured	Semi-structured
Purpose	Exploring the problem, gathering information.	Ask specific questions, gain a deeper understanding.
Number of interviews	8	5
Time	45 min	60 min
Roles	Purchasers at LA Source, Controllers at LA/GCC.	Purchasers at LA Source, System Support, Global Supply Planner and Master Planner GCC.

In Table 2.6 below, a detailed description of the roles of the interviewees can be found.

Table 2.6: Roles to be interviewed, and what the purpose of the role is.

Role	**Description of Role**
Purchaser at LA Source	Purchasers at Alfa Laval are responsible for ordering items and makes sure that these items are available for production. They are interviewed in order to find how the ordering process works and how they work when placing orders.
Controllers at LA/ GCC	The Controllers are the employees that are among other things, responsible for the financial aspects of Alfa Laval. They are interviewed in order to get a better understanding of certain parameters, such as EOQ.
System Support	System Support work with IT at Alfa Laval. They are interviewed in order to reach a deeper understanding of how the ERP system operates, how the different parameters, and their input variables, work.
Global Supply Planner	The Global Supply Planner is responsible for how many of a certain product Alfa Laval will produce. They are interviewed to get a better understanding of how Alfa Laval works with forecasting.
Master Planner GCC	The Master Planner is responsible for the planning of production for an entire factory, in this case, GCC. They were interviewed to get a better understanding of the underlying issues at Alfa Laval.

The data gathered from the interviews will mainly be used to answer RQ1 and RQ2, but also aid in understanding the current use of item classification for RQ3. In order to not single out any one employee, the data will be presented in a summarized fashion, without reference to individual interviews. Input from employees in several different positions at Alfa Laval will be gathered and cross-checked with the supervisor, in order to decrease the risk of participant bias and, in turn, increase reliability.

2.4.5 Software

Software used by Alfa Laval will be utilized to access data for the purposes of this thesis.

JEEVES

Alfa Laval in Lund uses the ERP system JEEVES which has support for several functions such as manufacturing, logistics, economics et cetera (JEEVES.com, n.d). In order to understand how the different parameters interact and affect the ordering process, how JEEVES operates needs to be understood. JEEVES will be used to extract data, review different parameters, and ensure that suggested solutions are possible to implement in practice.

ABC-Viewer

ABC-Viewer is a tool for creating ABC classifications and uses data from JEEVES. It will be used for simplifying data extraction, and eventually to create proposed categorizations.

Excel

Excel is used by Alfa Laval for a number of simple inventory management calculations. It will also be used by the authors in exploring and analyzing quantitative data.

QlikView

QlikView is used by Alfa Laval for more advanced calculations and visualizations, but also to store historical data.

2.5 Data Analysis

After gathering and compiling data, analyses will be performed with the purpose of identifying flaws and errors in the current setup. The main components of the data analysis will be mapping processes, reviewing parameters, and analyzing data extracted from JEEVES.

Yin (1994) describes four dominant techniques for analyzing case study evidence, namely:

- Pattern-matching
- Explanation-building
- Time-series analysis
- Program logic models

When pattern-matching, the researcher compares empirically based patterns with one or several predictions, with the aim of strengthening internal validity, which is further explained below. Explanation-building refers to a special type of pattern-matching mainly relevant to explanatory case studies, where the goal is to build an explanation about the case. Conducting a time-series analysis entails creating a timeline and analyzing a phenomenon over time, focusing on certain activities. Lastly, program logic models combine pattern-matching and time-series analysis in order to study patterns over time.

Data analysis in the thesis will generally use the technique of explanation-building, as the aim is to explain the phenomenon in question by establishing causal relationships between parameters. The chosen technique is also suitable for the abductive method this thesis employs, as it is iterative in nature. A potential issue is, as Yin (2018) notes, that it can be difficult to remain focused on the original topic of the issue during explanation-building, and constant reference to the original purpose must be made.

2.5.1 Mapping

With the help of interviews and data from the ERP-system JEEVES, the current ordering process will be mapped in order to understand the current state of the system. The approach for mapping processes will be further elaborated on in the theory chapter.

Mapping of a Purchaser's Ordering Process

By interviewing the purchasers at Alfa Laval, an overview of what the day-to-day work of a purchaser entails can be mapped. With this, it will be possible to create a map of how a proposal is handled and what the purchasers do when determining whether or not to realize the proposal.

Mapping of JEEVES Order Proposal Process

With data from JEEVES and interviews with system experts, a map of how JEEVES generates order proposals can be created. Mapping will make it possible to understand how the system thinks when it proposes an order for the purchasers.

2.5.2 Parameter Review

The various parameters used in the ordering process are one of the main focuses of this thesis. Initially, to understand how the current setup is performing, a detailed breakdown of the calculations and logic of the parameters will be performed. Then, drawing from data from interviews and concepts from the literature review, changes to the parameters will be proposed. Finally, the results of the proposed changes will be evaluated and compared to the performance of the current setup.

2.5.3 Item Classification

The current way of classifying items will first be reviewed and compared with concepts drawn from the literature review. Input from interviews will also be considered when proposing a new way of classifying items. Next, how the item classifications are used by Alfa Laval will be examined, with the goal of identifying improvement areas.

2.6 Credibility Criteria

According to Höst et al. (2006), there are three dimensions of credibility: reliability, validity, and generalization. The goal should be to reach a high level of credibility in all three dimensions. Table 2.7 provides a summary of the three credibility criteria, the main challenge of each criterion, and the specific strategy used to achieve credibility.

Table 2.7: A brief summary of the challenges and strategies for achieving credibility.

Criteria	Main Challenge	Strategy
Reliability	Participant bias	Conduct several interviews from different viewpoints, cross-reference data.
Validity	Measurement validity	Ensure collected data captures what it intends to, by analyzing the calculations behind the data.
Generalization	Context dependent	Describe the context in great detail to increase likelihood of achieving generalization.

2.6.1 Reliability

Reliability relates to the ability for an outsider or other researcher to replicate the experiment or analysis and get a consistent result, if another researcher is able to replicate the findings with the same method then the study is considered reliable (Saunders et al., 2016; Bell et al., 2015). The concept of reliability is split into two parts, external reliability, which refers to the aforementioned ability to replicate the research, and internal reliability, which examines if the different observers' or participants' stories are consistent with each other (Bell et al., 2015).

According to Saunders et al (2016), there are four threats to reliability, these are:

- Participant error
- Participant bias
- Researcher error
- Researcher bias

In this case, the participant refers to the interviewee. Because participants in this thesis might have personal opinions and viewpoints on the studied subject, participant bias is deemed to be a threat to the reliability of this report. Furthermore, researcher error is another threat to reliability, since the subject is complex and large amounts of data will be handled.

In order to achieve greater reliability and to negate the threats, more than one interview will be conducted with different people at different positions, and the different data will be reviewed multiple times with well-defined objective criteria in order to minimize the potential errors in the analysis and result.

2.6.2 Validity

Validity refers to how appropriate the measures used are, and how accurate the analysis of the results is (Saunders et al., 2016). Validity can be divided into measurement validity, which is concerned with if a measure captures what it intends to, internal validity, which is established when the research finds a causal relationship between two variables, and external validity or generalization, which is discussed in the next section (Saunders et al., 2016; Bell et al., 2015).

Regarding measurement validity, it is for example important to examine quantitative data extracted from JEEVES to ensure that the data actually contains the sought-after measures. This will be done by analyzing the calculations behind the data, to find any errors or misnomers. Internal validity can be achieved by testing the proposed modifications to the ordering process against the current setup to ensure that the desired results are reached.

2.6.3 Generalization

Generalization concerns the question of whether the findings from a study's research can be generalized to other relevant circumstances or organizations. This can be achieved by using representative samples for quantitative research. (Bell et al., 2015)

Generalization, or the ability to apply the findings of this thesis to other organizations or divisions at Alfa Laval, can only be reached to a certain amount in this thesis, as it is dependent on the context of the organization at hand. However, describing the specific context in great detail can increase the likelihood of achieving generalization to other divisions at Alfa Laval, where the context is similar to that of this thesis. (Höst et al., 2011)

3 Theory

In this chapter, the theory used throughout the thesis will be explained. The chapter is divided into sections depending on what area the theory is related to. Because the purchasing department at Alfa Laval is interwoven with inventory management to a large extent, concepts within both subjects will be explored and combined to create a comprehensive picture of purchasing at Alfa Laval.

3.1 The Ordering Process

The purchasing process is split into two different parts, tactical purchasing and the order function (van Weele, 2018). These two are in turn split into a number of sub-processes, from determining the specification of an item to follow-up and evaluation. This thesis focuses on the ordering processes located in the order function, which is highlighted in Figure 3.1.

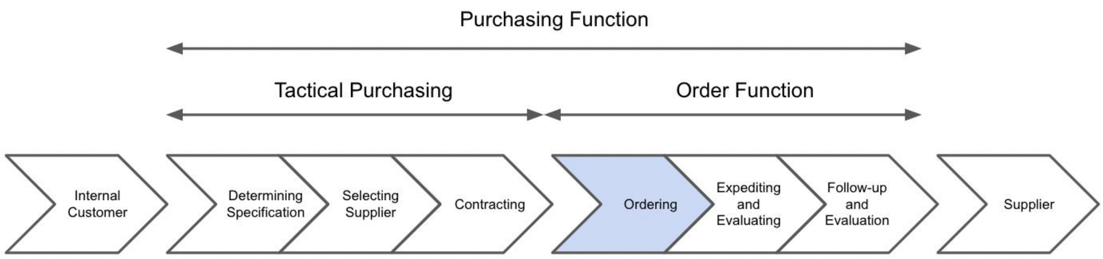


Figure 3.1: The placement of the ordering process within the purchasing process. Adapted from van Weele (2018).

Within the purchasing process, ordering is the process of placing an order with a supplier against certain specified conditions, commonly initiated digitally by an ERP or an MRP (van Weele, 2018). The ordering process can have various characteristics and can be initiated by a number of triggers, which will be explained below.

3.1.1 Types of Purchases

Purchases generally fall into three different categories, *Straight Rebuy, Modified Rebuy* or *New Task* according to Figure 3.2. These go from simple, everyday purchases that have low risk, to purchases that are complicated or demanding and carry high risk (van Weele, 2018; Osmonbekov & Johnston, 2018).

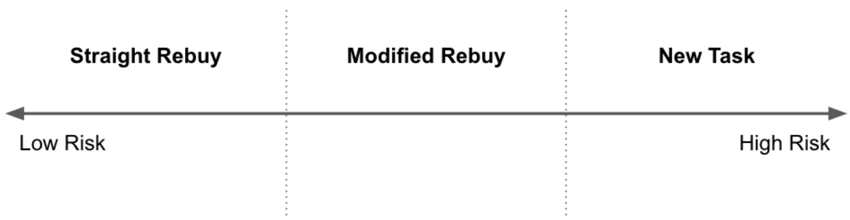


Figure 3.2: The different purchasing situations and their risks, adapted from van Weele (2018).

Straight Rebuy

The straight rebuy situation is the most common of the three situations. It arises when purchasing a known product from a known supplier. The uncertainty of the outcome is therefore low since the product and the supplier are known in advance. Here, speed and efficiency are sought after as these products are most often routine items (van Weele, 2018). Moreover, there are often fewer persons involved in these purchases and they are not being evaluated to the same extent as they are considered low risk (Osmonbekov & Johnston, 2018). Straight rebuys are therefore possible and desirable to automate in the future (Gottge, Menzel & Forslund, 2020).

Modified Rebuy

Modified rebuy is when the company purchases either a new product from a supplier they have worked with before or a product they have bought before from a new supplier. This situation usually occurs when the company is not satisfied with the service of the old supplier and is looking for other options (van Weele, 2018).

New Task

The new task situation occurs when the company purchases a new product from a supplier they have not worked with before. Since the characteristics of the product still need to be understood, as well as how the supplier delivers, this situation carries the most risk of failure (van Weele, 2018). Furthermore, the company often lacks purchasing procedures for the new task contributing to the increased risk and when the purchase moves from straight rebuy into a new task situation, more people from different parts of the organization get involved, such as engineers or other technical personnel from different departments (Osmonbekov & Johnston, 2018).

Purchases Handled in this Thesis

The purchases handled in this thesis fall into the straight rebuy category as known products and known suppliers are involved. Therefore, negotiating new contracts with different suppliers is considered to be out of scope.

3.1.2 Order Triggers

The ordering procedures can be triggered by a variety of things. In this part, three of these triggers will be explored.

Orders Triggered by Customer Orders or Forecasts

Depending on where the decoupling point is, as explained below, different customer orders can trigger a restock which is especially true when the customer orders a newly developed product. Furthermore, forecasts can give an indication of whether or not the item needs to be restocked to keep up with a future increase in demand (Monczka et. al, 2016).

Orders Triggered by Stock Checks

In smaller companies, it is not unusual to use a physical stock check to determine the amount needed to be ordered. Stock checks can also be used to determine if the inventory level matches the inventory that is recorded in the system (Monczka et. al, 2016)

Orders Triggered by a Reorder Point System

A reorder point system is often used in companies to keep track of their inventory needs. This system extracts information regarding the inventory and when the inventory goes below a given point, an automatic inventory restock trigger is sent to a purchaser or directly to a supplier. This system is the most common one for checking and maintaining inventory levels and is also the primary system that Alfa Laval uses and will therefore be discussed more in-depth in later chapters (Monczka et. al, 2016; van Weele, 2018).

3.2 Inventory Management

There are three main questions that inventory management aims to answer (Olhager, 2019):

- How much should be ordered?
- How should uncertainty be handled?
- How should orders be initiated?

The following sections will further elaborate on each question, respectively.

3.2.1 Economic Order Quantity (EOQ)

A common way of determining order quantity is by using EOQ and balancing the carrying cost of inventory against the cost of replenishment orders and/or production set-up costs (Christopher, 2011). The EOQ model assumes that annual usage and inventory carrying cost is constant, ordering cost is independent of order quantity and the EOQ can be determined by Equation 1 (Olhager, 2019).

$$EOQ = \sqrt{\frac{2AS}{iV}} \tag{1}$$

Where,

$$A = annual\ usage$$
$$S = ordering\ cost/setup\ cost$$
$$i = inventory\ carrying\ cost$$
$$V = product\ value$$

Ordering Cost

The ordering cost or setup cost refers to the one-time cost that occurs when handling an order. Jonsson & Mattsson (2011) identifies two main components in the ordering cost: material handling and order handling costs. Material handling refers to activities such as receiving, inspecting, and storing goods. Order handling consists of activities related to administering an order, such as maintaining supplier relationships and handling requisitions.

Inventory Carrying Cost

Inventory carrying cost is the cost related to keeping an item in inventory and consists of three components according to Jonsson & Mattsson (2011): storing cost, uncertainty cost, and capital cost. Storing cost contains costs related to the storage area, as well as maintaining stock in the area. Uncertainty cost is derived from the risk and uncertainty related to keeping stock, for example, costs of obsolescence and waste. Finally, capital cost relates to the alternative cost of keeping stock instead of making another investment. The capital cost is often set internally as a way of controlling how much stock is being kept (Axsäter, 2006).

Cost of ordering the EOQ

The cost of ordering the EOQ can then be derived to Equation 2 (Muckstadt & Sapra, 2010):

$$C(EOQ) = \sqrt{2ASiV} \tag{2}$$

The total cost is relatively insensitive to changes in order quantity and errors in estimates of cost parameters as shown in Figure 3.3, meaning that the EOQ is a good proximity value even if not all parameters are correct (Muckstadt & Sapra, 2010; Olhager, 2019). The EOQ method is however quite basic, which means that other factors such as limitations in process technology, supplier requirements such as Minimal Order Quantity (MOQ), and other practical perspectives are often included in real-life models (Olhager, 2019).

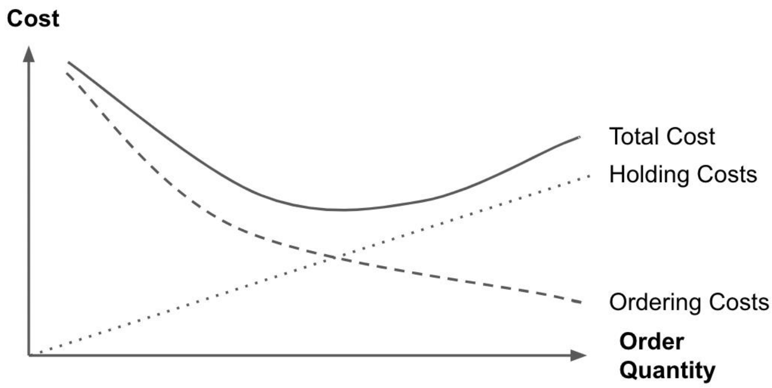


Figure 3.3: Cost elements as functions of the order quantity. Adapted from Olhager (2019).

In real-life scenarios the ordering cost and holding cost are often estimated, resulting in a fuzzy estimate. Vujošević, Petrović & Petrović (1996) presents several EOQ models that take this into account. By assuming the fuzzy numbers have uniform distributions of probabilities between two boundaries, their findings can be simplified by de-fuzzing the input costs immediately and using the normal EOQ model. This is done by simply using the average of the initial fuzzy estimate.

EOQ With Quantity Discounts

A further expansion of the EOQ model is to include quantity discounts, which commonly occur in reality. This model includes breakoff points which are the amounts where additional quantity discounts are given. By minimizing the cost for each price interval, shown in Equation 3, a new EOQ can be found. (Olhager, 2013)

$$C_{j,tot} = S\frac{A}{Q} + ic_j\frac{Q}{2} + c_jA, j = 1, \ldots, j \quad (3)$$

Where,

$$C_{j,tot} = Cost\ for\ the\ different\ quantity\ intervals$$
$$Q = Order\ Quantity$$
$$c_j = The\ cost\ per\ piece\ for\ the\ units\ when\ ordering\ j\ amount$$

Figure 3.4 depicts the resulting total cost curves in the case of two breakoff points. Each line, $C_{j,tot}$, refers to one price level, and the wider line parts represent the actual total price. By minimizing the above equation for each segment and finding the amount that incurs the lowest total cost, the optimal quantity when quantity discounts are taken into consideration can be found (Olhager, 2013).

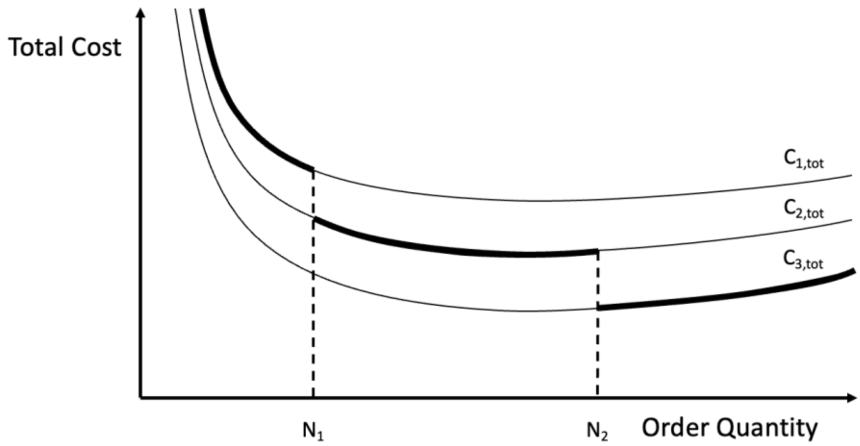


Figure 3.4: Total cost as a function of order quantity, in the case of two breakoff points. Adapted from Olhager (2013).

3.2.2 Safety Stock (SS) and Service Level (SL)

SS is used to compensate for uncertainty in forecasts and to avoid shortages in supply. It can also be of use in case there is a difference between actual inventory and inventory in the planning system. The most common way of determining SS is to set the desired SL and calculate the probability of not having a shortage of supply during an order cycle, also called the SERV1 definition. The SS is determined as a safety factor multiplied by the standard deviation of the forecast error during the lead time, according to Equation 4. (Olhager, 2019)

$$SS = k \cdot \sigma_L = k \cdot \sigma \cdot \sqrt{L} \tag{4}$$

Where,

$$SS = safety\ stock$$
$$\sigma = standard\ deviation\ of\ the\ forecast\ error\ per\ forecast\ period$$
$$\sigma_L = standard\ deviation\ of\ the\ forecast\ error\ during\ the\ lead\ time$$
$$k = safety\ factor, obtained\ from\ a\ statistics\ table$$
$$L = lead\ time\ in\ number\ of\ forecast\ periods$$

Table 3.1: Examples of the relationship between SL and safety factor at normal distribution. Adapted from Olhager (2019) and Axsäter (2006).

Service level	50 %	75 %	80 %	85 %	90 %	95 %	97,5 %	99 %
Safety factor (k)	0	0,67	0,84	1,04	1,28	1,65	1,96	2,33

SL is used in order to know how often the demand can be satisfied. More specifically, SL will from here on use Axsäter's (2006) definition "the probability of no stockout per order cycle". Having a higher SL is associated with a higher safety factor and a higher cost, which can be noted in Table 3.1 where the safety factor increases the higher service level one desires. Some companies use a set number of weeks of supply, or other less theoretically correct methods for calculating SS, which can lead to very poor and costly results (Muckstadt & Sapra, 2010).

In some cases, companies will use Mean Average Deviation (MAD) instead of standard deviation. This measure is easier to calculate and can relatively easily be translated to standard deviation. Standard deviation emphasizes outliers in the data set compared to MAD (Rousseeuw & Croux, 1993), which is why an extra deviation factor of 1,25 is added as shown in Equation 5. The deviation factor depends on the distribution of the data but varies between 1,2 and 1,3 which is why the approximate value of 1,25 is commonly used. (Olhager, 2013)

$$MAD = 1{,}25 \cdot \sigma \tag{5}$$

3.2.3 Reorder Point (ROP)

The most common method for inventory management is using an ROP (Olhager, 2019). With this method, a purchasing order is generated when the inventory level plus any outstanding orders reach a predetermined ROP, calculated as shown in Equation 6. (Muckstadt & Sapra, 2010; Olhager, 2019)

$$ROP = SS + D \cdot L \tag{6}$$

Where,

$$ROP = reorder\ point$$
$$SS = safety\ stock$$
$$D = demand\ per\ period$$
$$L = lead\ time\ in\ number\ of\ periods$$

Using this method in ideal conditions, the SS is never used. However, if demand during the lead time is larger than the forecast, or if the lead time is longer than expected, the SS is used. An alternative way of expressing the ROP is using ROT, meaning the amount of time the current stock level is expected to last, as shown in Equation 7. (Olhager, 2019)

$$ROT = \frac{I}{D} \tag{7}$$

Where,

$$ROT = run\ out\ time$$
$$I = available\ inventory\ level$$
$$D = expected\ demand\ per\ period$$

The ROP and ROT methods are most suitable for items with independent and even demand, as otherwise the safety stock levels will be too large to be economically viable. (Olhager, 2019)

3.2.4 Decoupling Point

The decoupling point is where the manufacturing and construction of a product are determined by customer specifications (Jonsson & Mattson, 2016). Before the decoupling point, items are purchased or made to stock, called MTS or PTS. After the decoupling point, items are purchased or made to customer orders, MTO or PTO (Olhager, 2013). Furthermore, the position of the decoupling point also determines where the forecast should be used to determine demand, but also whether a lean or agile strategy in the supply chain should be implemented (Christopher, 2011). It is also possible to use a so-called “leagile” approach where you build an agile strategy on a lean platform. This would mean that before the decoupling point the strategy is to be lean and after the decoupling point the strategy is to be agile (Christopher, 2011; Olhager, 2010). Therefore, the further downstream the decoupling point is, the more emphasis is placed on using forecasts when working with purchasing.

3.3 Inventory Classification

In this section, the ABC classification, the extension of ABC classification called ABC-XYZ classification, and how to integrate demand forecasts into different classifications will be explored.

3.3.1 ABC Classification

The conventional ABC classification is a widely used approach for classifying items based on their value or other factors. The basis of ABC classification is the Pareto Principle, the idea that 20% of inventory commonly stands for 80% of revenue. Using the Pareto Principle, it is possible to split inventory into three different groups, A, B, and C where A is high volume inventory that accounts for 80% of the total, B is the medium volume that accounts for 15% and C is the low volume that accounts for 5% (Stojanović & Regodić, 2017; Flores & Whybark, 1986; Jonsson & Mattsson, 2016). Even though there are other versions of ABC classifications, the general idea is the same across versions (Ng, 2007).

The traditional method is not very flexible, as it only accounts for one dimension. To solve this issue, Flores and Whybark (1986) were the first to suggest that more criteria could be added to the analysis in order to give it more depth. The examples given in the study are that a company may want to use dollar usage together with either lead time or obsolescence, but that it can be customized to fit the needs of the business (Flores & Whybark, 1986). The model was then further extended with the use of multicriteria decision-making tools (Ramanathan, 2006), which will not, however, be covered in this thesis.

3.3.2 ABC-XYZ Classification

A common extension of an ABC classification is using an ABC-XYZ classification, which extends the ABC model by including the dynamics of the consumption of the items using XYZ classifications. The XYZ classification divides the items into three groups based on the demand variability of the items weighed against average demand, with X items having the lowest and Z items the highest variability. This is done by first calculating the standard deviation according to Equation 8, and then the CDV according to Equation 9 (Stojanović & Regodić, 2017)

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})^2} \tag{8}$$

Where,

$$\sigma = standard\ deviation$$
$$x_i = individual\ values$$
$$\bar{x} = average\ value$$
$$N = total\ number\ of\ observations$$

$$CDV = \frac{\sigma}{\bar{x}} \tag{9}$$

Where,

$$CDV = Coefficient\ of\ demand\ variation$$

Items are then ranked into groups based on their CDV. While the rankings are arbitrary and depend on the specific context, Scholz-Reiter et al. (2012) propose the following division:

- Classification X: CDV < 0.5.
- Classification Y: CDV between 0.5 and 1.
- Classification Z: CDV > 1.

CDV has also been shown to be an important indicator of the MTS or MTO decision (Wanke & Zinn, 2004), as a higher CDV means that a too high SS will be needed when applying MTS. When using XYZ classification to determine whether an item should be MTS or MTO, D'Alessandro & Baveja (2000) proposes the following division:

- MTS: CDV < 0.5.
- MTO: CDV > 0.5.

Wanke & Zinn (2004) further concludes that CDVs over 0,9 indicate that an item should always be made-to-order, no matter what other factors might indicate. Whatever criteria is chosen, the nine resulting classifications are presented in a matrix in Table 3.2. The ABC classification is commonly applied as the primary analysis, and the XYZ classification is used as a supporting analysis (Scholz-Reiter et al., 2012).

Table 3.2: Classifications in an ABC-XYZ analysis. Adapted from Stojanović & Regodić (2017).

	A (high)	**B (average)**	**C (low)**
X (high)	A/X	B/X	C/X
Y (average)	A/Y	B/Y	C/Y
Z (low)	A/Z	B/Z	C/Z

In general, the green classifications, A/X, B/X, and A/Y, are most appropriate for JIT approaches, and efforts towards improving inventory management should be focused on these classifications due to their high impact on profitability and high predictability. The red classifications, B/Z, C/Y, and C/Z on the other hand, have low impacts on profitability, are difficult to forecast, and improving inventory management for these classifications should therefore not be prioritized. The remaining blue classifications, A/Z, B/Y, and C/X, need to be individually examined to determine the best approach. (Stojanović & Regodić, 2017)

Other contextual factors also need to be considered when determining the optimal inventory management strategy. Besta et al. (2012) state that items that are essential might need adequate safety stocks, and lead times that are long or have a high variability can cause issues.

Some challenges and drawbacks for ABC-XYZ analysis include (Dhoka & Choudary, 2013):

- What time frame should be set for calculating standard deviation, and for the analysis as a whole? Can be yearly, monthly, weekly, or any other time period.
- How should the classification of new products be set up?
- How should the rankings be set? There are no industry standards, and optimal divisions might require iterative adjustments.
- Seasonality in demand can be overlooked, meaning that seasonal items might need to be classified differently during the year.
- The classifications need to be periodically reviewed and updated, preferably monthly, quarterly, or at least yearly. (Scholz-Reiter et al., 2012).

3.3.3 Integration of demand forecasts in ABC-XYZ analysis

Another extension of the ABC-XYZ analysis was proposed by Scholz-Reiter et al. (2012) who integrated demand forecasts into the model. Demand forecasts were used to make the classification process more precise by taking future trends into account, and the resulting classification was in a case study shown to be around 23 percent more accurate. Updating classifications yearly was found to be insufficient, and monthly updates are therefore recommended.

Demand forecasts tend to get less accurate over time, and the optimal number of future time periods to be included in the classification must therefore be found for each specific business context. First, a reference classification is created using the actual consumption of the item during the 12 previous time periods analyzed, as shown in Figure 3.5(a). Next, classification 1-7 is created, integrating an increasing number of time periods into the classification. The past classification, meaning the classification currently in use, is then created. Classification 1-7 and the past classification is then compared to the reference classification in terms of which items end up in the same categories, to seek out the optimal amount of demand forecasts to integrate into the classification, as well as compare the method to the current setup.

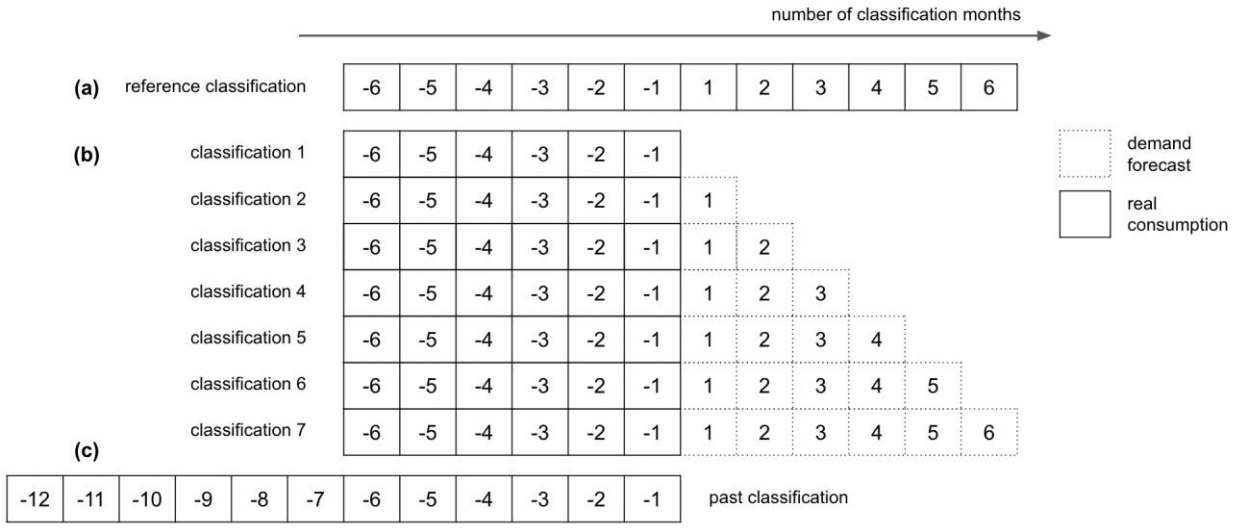


Figure 3.5: Comparison of the reference classification and past classification with the ABC-XYZ classification including demand forecasts. Adapted from Scholz-Reiter et al. (2012).

The correspondence of classification one through seven with the reference classifications can then finally be mapped out in a graph to determine the optimal amount of months demand forecasts to integrate into item classification. An example of how this graph might look can be found in Figure 3.6, where 5 months of demand forecasts were found to be optimal, resulting in correspondence of around 92 % with real consumption data.

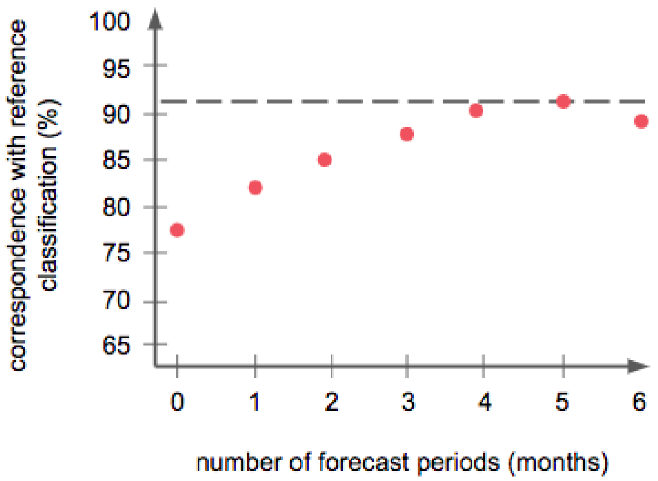


Figure 3.6: Example of correspondence of classification 1-7 with the reference classification. Adapted from Scholz-Reiter et al. (2012).

3.4 Process Mapping

Process mapping is used as a visual tool for creating a shared understanding of the existing processes and improving upon them. Furthermore, it can be said that process mapping is a tool for “reducing waste and improving efficiency and effectiveness in a process” (Conger, 2011). Kalman (2002) states that process mapping involves creating a macro-map, identifying existing bottlenecks, constructing a micro-map to find root causes to the bottlenecks, and iteratively redesigning the process. Many variants of process mapping exist, providing different perspectives, but the one that is used by this thesis is the flowchart which is suggested by Damilio (2011) to use when mapping value- or nonvalue-adding work performed. The flowchart will be further elaborated on, as well as the icons commonly used to build the process maps (Conger, 2011).

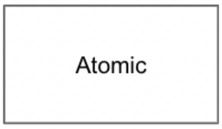
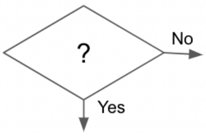
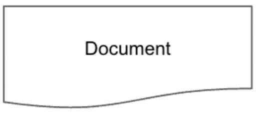
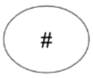
3.4.1 Relevant Icons

When creating a process map it is important to use icons that are universal and recognizable across industries. Activities in the process are represented by some sort of icon (Conger 2011; Damilio, 2011). These icons describe the input, output and what kind of work is being done, however, they do not describe in what quantities the work is being done, or how effective the process is (Damilio, 2011). According to Conger (2011) the icons represent four different activities or interactions, these are:

- Providing or creating material or information
- Using the providing or created information or material
- Receiving material or information
- Storing material or information.

The symbols relevant to this thesis are shown and explained in Table 3.3 below.

Table 3.3: Process icons relevant for this thesis. Adapted from Conger (2011).

Icon	**Type**	**Description**
	Start or Stop	This icon signifies the start or stop of a process or activity.
	Flow	Defines the way in which the process goes from one step to the next.
	Process	An atomic process is a process that cannot be divided into smaller subprocesses.
	Process	A non-atomic process is a process that consists of several atomic processes.
	Process	A process that is conducted automatically by a computer or other software.
	Decision and Condition	Indicates a decision or a conditional process step. If the condition is fulfilled, the process proceeds down the “Yes” path, otherwise it continues in the “No” direction.
	Document	Used to denote a document either generated by a computer or created by hand
	Connection	Depicts a connection between two different parts of a diagram.

3.4.2 Decision Flowchart

The American National Standards Institute has developed a decision flowchart that can be used to identify decision steps and alternative process paths (Chapin, 1970). The method gives a quick, graphic overview of the process, and also includes decision making that is used when producing or creating a specific output. By using a flowchart, it is possible to identify potential waste and nonvalue-adding activities and eliminate those (Damelio, 2011). An example of a decision flowchart for making breakfast can be found in Figure 3.7.

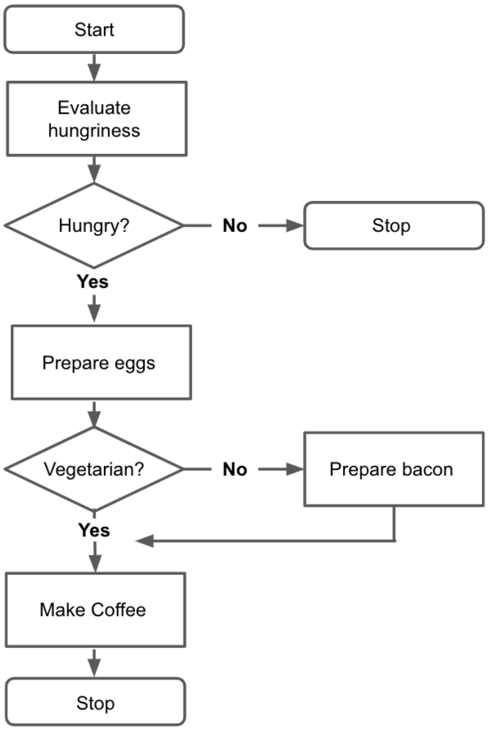


Figure 3.7: Example of a decision flowchart for making breakfast. Adapted from Kalman (2002).

3.5 SWOT Analysis

In order to gain a quick understanding of the strengths, weaknesses, opportunities, and threats of a company, a SWOT analysis can be performed. A SWOT analysis looks at the internal and external environment of a company and provides a way of identifying and categorizing factors affecting the company. While some argue that the SWOT analysis is not complex enough to deal with the intricacies of today’s business environment, it can still be useful as a method for quickly organizing one’s thoughts. (Panagiotou, 2003). An example of a SWOT analysis can be found in Figure 3.8.

Figure 3.8: The layout of a SWOT analysis.

3.6 Use of Theory

The presented theory will be utilized to analyze empirical data and the research questions in order to fulfill the purpose and answer the research questions of this thesis. Figure 3.9 gives a brief summary of the different sections in this chapter, and how they will be used in analyzing the research questions.

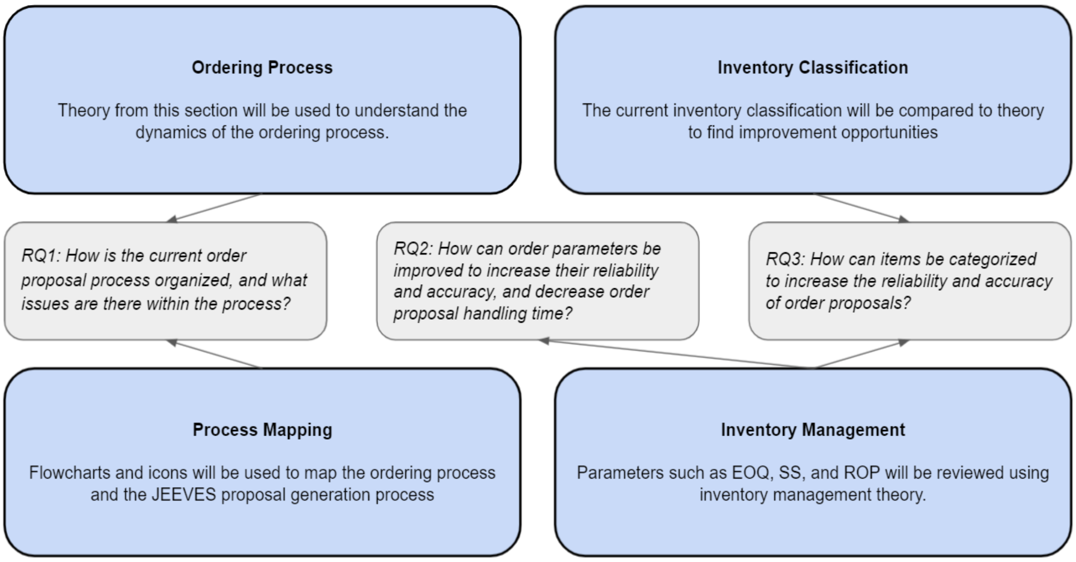


Figure 3.9: A brief summary of theory sections and how they will be used in analyzing the research questions.

4 Empirical Data

This chapter presents empirical data gathered by the authors starting with mapping of processes, parameters, and inputs. Next, the current item classification is discussed, as well as ideas for future classifications. Finally, quantitative data on historical item demand is presented.

4.1 Ordering Process

The ordering process is defined as the operational part of the purchasing process, i.e. choosing the correct order proposal for the current need of a specific item.

4.1.1 Ordering Process Mapping

Applying a Decision Flowchart described in section 3.4.2, the current ordering process at Alfa Laval was mapped, resulting in the process map in Figure 4.1 consisting of four main subprocesses. The process map is based on information gathered during the initial round of interviews with employees in the purchasing department. Each individual step of the purchasing process will now be further described.

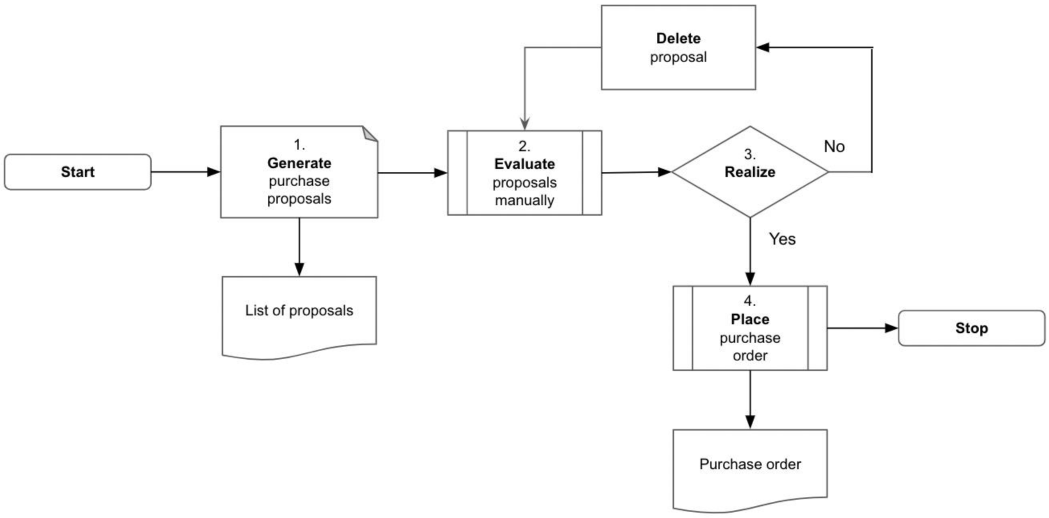


Figure 4.1: Process map of the ordering process at Alfa Laval.

1. **Generate purchase proposals**

Purchase proposals are generated automatically in JEEVES, and a list of proposals is presented to the purchaser. This subprocess will be described in more detail in section 4.2.

2. **Evaluate proposals manually**

The purchase proposals are then evaluated manually by the purchaser, to determine their fit towards current inventory levels, planned customer orders, and forecasts of future demand. Some proposals are immediately deemed irrelevant and not further investigated, and others are more deeply analyzed. This subprocess is the most time-consuming, especially considering the problem with JEEVES proposing irrelevant orders.

3. **Realize**

If the proposal is fit for operations it is realized, moving on to the next step of the process. If not, the proposal is deleted and another proposal is chosen for evaluation.

4. **Place purchase order**

In the final step, relevant orders are placed by the purchaser, resulting in a purchase order.

4.1.2 Purchasing Styles

During the first round of interviews conducted, different purchasing styles were identified. Purchasing styles in this case refers to how individual purchasers approach purchasing, and what goals they aim to fulfill. It was found that purchasers at Alfa Laval have quite different approaches and goals, and the extremes of these approaches are presented below. Purchases made with these extremes do not follow the suggestions made by JEEVES, resulting in a less data-driven ordering process.

Purchasing Style A

This purchaser finds the ordering process time-consuming and wants to minimize the amount of time spent on an order. This leads to the purchaser wanting to order each item fewer times, and therefore larger quantities in each order. In summary, the result is larger average inventories for all items and sub-optimal purchasing behavior.

Purchasing Style B

This purchaser knows about Alfa Laval's efforts to decrease inventory levels and aims to keep stock levels as low as possible. He or she does so by ordering small quantities of each item frequently. The problem with this purchasing style is that too much time might be spent on the ordering process, and there is no distinguishing between items that should be kept at a low stock level, and items that must always be available.

4.1.3 KPIs for the Purchasing Department

KPIs are deemed relevant to RQ3 of this thesis, as item categories can be used to set more specific goals for KPIs, in turn motivating the implementation of item categories. Information on the KPIs used at LA was gathered in the first round of interviews. The three KPIs presented in Table 4.1 are used at LA, throughout all departments. They are broad and do not only relate to the work of the purchasing department but are used by them nonetheless. Notable is that OP F&E is greatly affected by sales volumes, and IDS includes time spent in production, which makes these KPIs less relevant for the purchasing department.

Table 4.1: KPIs at Alfa Laval.

KPI	Description	Explanation
OP F&E	Operating Factory & Engineering Result	Measures the total profit of the LA factory.
OFLTd	Order Fulfillment Lead Time Discrepancy	Measures the lead time towards customers compared to the desired lead time.
IDS	Inventory Days of Supply	Measures how many days of supply an item has, throughout the whole factory.

4.2 JEEVES Proposal Generation

The proposal generation in JEEVES was mapped, and the parameters used in JEEVES were investigated, to gain a deeper understanding of the current setup. The proposal generation process and the parameters were examined through observations of the system, complemented by exploratory interviews during the first round.

4.2.1 Current Parameters

The following parameters are currently calculated within JEEVES and used in the purchase proposal generation. JEEVES draws item data from seven separate databases for calculating parameters, divided according to Alfa Laval's internal business units. The abbreviations are used by Alfa Laval and will for simplicity from here on be used in the same fashion.

Safety Stock (SS)

SS is the stock level required to not run out of stock at the probability of the chosen SL and is calculated monthly in line with the theory presented in section 3.2.2, with some modification according to Equation 10. (Olhager, 2019)

$$SS = k \cdot d \cdot MAD \cdot \sqrt{L + R} \tag{10}$$

Where,

$$SS = safety\ stock$$
$$k = safety\ factor, obtained\ from\ a\ statistics\ table$$
$$d = deviation\ factor = 1{,}25$$
$$MAD = Mean\ Absolute\ Deviation, monthly\ basis$$
$$L = lead\ time\ in\ number\ of\ forecast\ periods\ (months)$$
$$R = review\ time\ in\ number\ of\ forecast\ periods = 0{,}05\ months$$
$$x_i = Usage\ of\ item\ in\ month\ i$$
$$\bar{x} = average\ usage\ during\ n\ months$$

MAD, calculated on a monthly basis, times a deviation factor of 1,25 is used due to limitations in JEEVES where it is not possible to calculate the standard deviation. This follows Olhager's (2013) reasoning regarding deviation factors. Review time is a set time added to all items, to account for the time it takes to receive and review them. Finally, the safety factor is set according to an ABC analysis, as shown in Table 4.2. The analysis is based on an accumulated percentage of order lines and follows the Pareto principle. The service levels have been set to a satisfactory amount by Alfa Laval. Notable is the fact that this ABC classification is not coherent throughout inventory management at Alfa Laval.

Table 4.2: ABC-classification for safety factors, based on an accumulated percentage of order lines.

Classification	Percentage	Service Level	Safety Factor
A	80%	98,2%	2,1
B	95%	98,2%	2,1
C	100%	95,1%	1,65

Economic Order Quantity (EOQ)

EOQ is the amount that is most efficient to order and is used the same way as in the theory presented in section 3.2.1, using Equation 1 (Olhager, 2019). However, two of the input variables in the EOQ, the *ordering cost* and the *stock keeping interest*, were set around 20 years ago and have not been changed since then.

$$S = ordering\ cost = 325\ SEK$$
$$i = stock\ keeping\ interest = 40\%$$

Reorder Point (ROP)

The *ROP* denotes the point at which an item is supposed to be reordered. In JEEVES this is calculated as per Equation 6, in line with the presented theory in section 3.2.3 (Muckstadt & Sapra, 2010; Olhager, 2019). The demand is forecasted on a yearly basis and divided by the number of working days per year and multiplied with the planning lead time to receive a forecasted demand per period.

Optimal Stock Level (OSL)

The *OSL* is a parameter used by purchasers to evaluate current stock levels. It is simply the midway point between the SS and the EOQ as shown in Equation 11 and is considered the theoretically optimal stock level.

$$OSL = SS + \frac{EOQ}{2} \tag{11}$$

Forecasts

Forecasting is performed on both a unit level and an item level. On a unit level, the number of units that are expected to be sold is forecasted on a monthly basis using software called SO99. SO99 forecasts are considered to be accurate, however, there are currently no tools to translate these unit forecasts to item level. Therefore, an Excel tool is used to find an appropriate forecast on an item level based on historical data and using several different analysis methods such as:

- Single exponential smoothing
- Double exponential smoothing
- Moving average 12-/5-/3-months
- Weighted average

The most accurate of these forecasts are then scripted into JEEVES, by comparing historical data and forecasts. These forecasts are performed on a 12-month basis and are later used to set different parameters, such as the ROP.

4.2.2 Inputs in JEEVES

These values are input into JEEVES and used for the previously described calculations. The values are input from suppliers, set by purchasers, or forecasted.

Minimal Order Quantity (MOQ)

MOQ is negotiated with Alfa Laval's suppliers and is set by strategic purchasers. They try to find a cost-effective solution by balancing quantity discounts with the EOQ for the item in question. Not all items have a *MOQ*, but in case they do this is the minimum amount that is possible to order.

On-Hand

On-Hand is the amount of the specific item that is currently in stock.

Lead Time Limit (LTL)

The amount of time that the stock of the item is planned in advance. The LTL is set by the purchaser in charge of the specific item.

Reservations within Lead Time Limit (RES_LTL)

The reserved amount of a specific item within the LTL.

Replenishments within Lead Time Limit (Repl_LTL)

The amount of the specific item planned to be restocked or replenished within the LTL.

All Replenishments (Repl_ALL)

The amount of the specific item planned to be restocked or replenished, independent of the LTL.

Demand During Lead Time (DDLT)

DDLT measures how much demand is forecasted to be during the LTL and is based on a yearly forecast for the item. This is in line with the presented theory, with a yearly forecast and the time period set to LTL according to Equation 12.

$$DDLT = \frac{Yearly\ forecast}{Calendar\ Days\ \cdot LTL} \tag{12}$$

4.2.3 Proposal Generation Mapping

Using process mapping, the proposal generation that is conducted by JEEVES was also mapped and can be seen in Figure 4.2. The process described is for the proposal generation done in JEEVES. Alfa Laval is currently in the process of implementing a new ERP, Microsoft Dynamics, and therefore this process might change with the new system. An explanation of the process will follow after the figure.

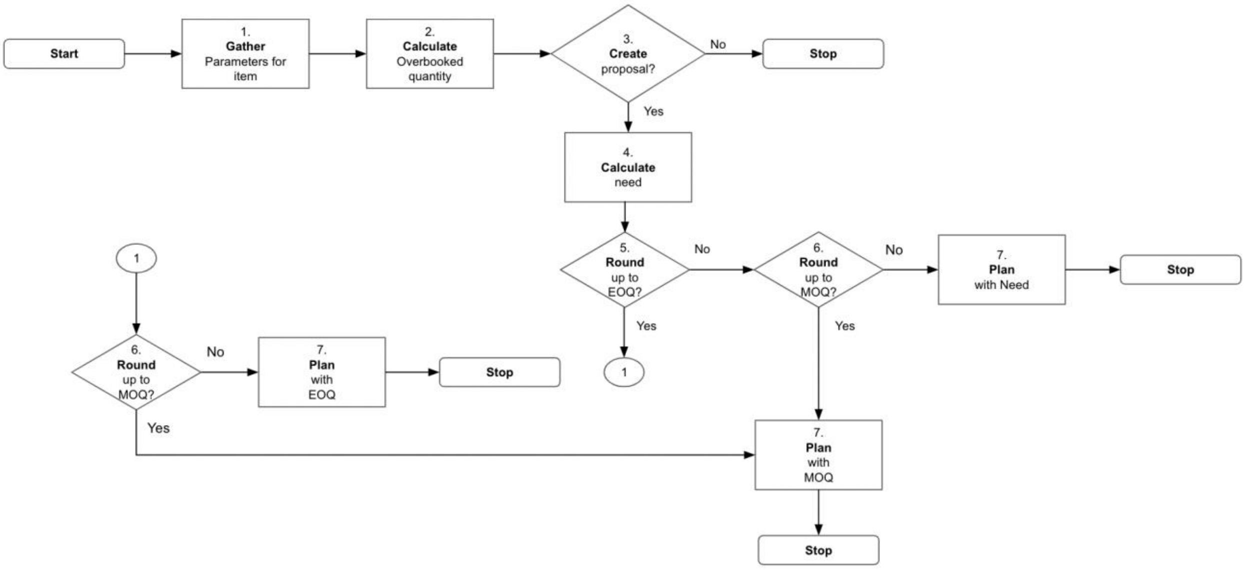


Figure 4.2: The proposal generation that is performed automatically by JEEVES.

1. **Gather Parameters for item**

The system gathers different parameters that are relevant to this item.

2. **Calculate Overbooked Quantity**

JEEVES calculates if the item is overbooked. In practice, this means that if the item is reserved in a larger quantity than the forecasted demand during the LTL, the item is considered overbooked. The overbooked quantity is calculated as RES_LTL minus DDLT.

$$IF(RES\_LT > DDLT);\ Overbooked\ = RES\_LTL - DDLT$$

3. **Create a Proposal?**

Checks if the On-hand inventory combined with Repl_ALL are larger than the ROP. If not, JEEVES generates a purchasing proposal.

$$IF(Current\ inventory\ +\ Repl\_ALL\ -\ Overbooked\ > ROP);\ Generate\ Proposal$$

4. Need for the item?

The amount needed for the specific item is calculated. If there is a need, JEEVES continues to the next step of the process.

$$Need = SS + MAX(DDLT;\ RES\_LTL) - On\ Hand - Repl\_LTL$$

5. Round up to EOQ?

If the item's EOQ is larger than the needed amount, JEEVES increases the quantity to be purchased to the EOQ.

$$IF(EOQ > Need);\ Quantity = EOQ$$

6. Round up to MOQ?

If the item’s MOQ is larger than the needed amount and the EOQ, then JEEVES uses the MOQ to define what quantity to purchase according to Equation xx.

$$IF(EOQ < MOQ\ OR\ Need < MOQ);\ Quantity = MOQ$$

7. Suggest Order

JEEVES suggests the order to the purchaser with either the needed quantity, EOQ or MOQ, depending on the result of the previous steps.

Summary

In summary, JEEVES sends a proposal to the purchaser when an item's inventory level goes below the ROP and the quantity in the proposal is the largest out of Need, EOQ, and MOQ.

4.3 Current Classification of Items

Alfa Laval are currently classifying their items into a standard ABC classification and as of writing this thesis, there are talks about implementing a more comprehensive analysis based on double ABC, or ABC-XYZ, analysis. This was gathered during the first round of interviews based on the experience of purchasers at Alfa Laval and will be further elaborated upon in section 4.3.2.

4.3.1 Classifying items into ABC Classifications

The items at Alfa Laval are currently either classified based on volume value, as per Equation 13 or based on order lines per item, as per Equation 14.

$$volume\ value\ =\ \#\ items\ demanded\ \cdot cost\ per\ item \tag{13}$$

$$percentage\ of\ total\ order\ lines\ = \frac{order\ lines\ of\ item}{total\ amount\ of\ order\ lines} \tag{14}$$

These are then split into ABC classifications based on the Pareto principle discussed in the theory chapter. The basis for the classifications varies between safety stock calculations and in JEEVES, which is suboptimal from a management perspective.

4.3.2 Proposal, Batch, or Shortage

Alfa Laval have previously gathered that a basic ABC classification is not good enough, which is why a new classification system is under discussion. Alfa Laval have noticed three distinct demand patterns that they want to base their new item categories around, called Proposal, Batch, and Shortage, as shown in Figure 4.3. How to divide items systemically into the three identified categories will further be discussed in the analysis chapter.

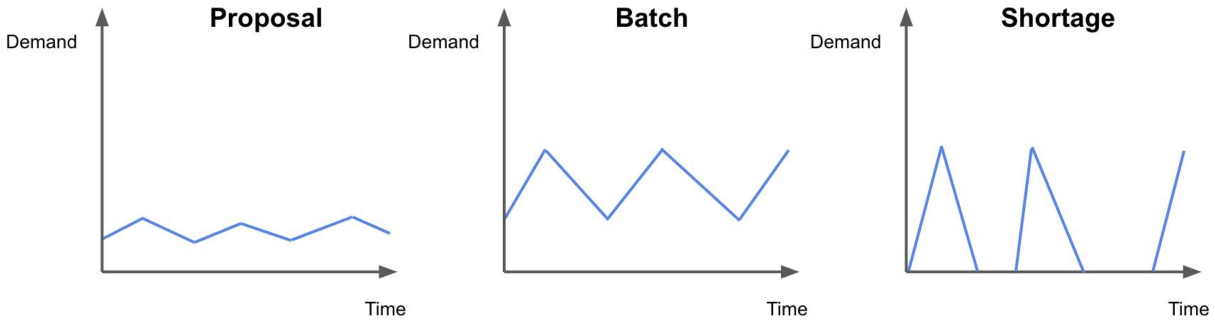


Figure 4.3: The proposal generation that is performed automatically by JEEVES.

Proposal

Proposal is suggested to include items that have a stable demand which does not change over time. Moreover, these items are the ones that have the highest volume value, meaning they can include items that have a high volume with lower value and those with higher value and lower volume.

Batch

Batch are the items that have a larger variance in the demand pattern than the proposal items, while simultaneously having a relatively lower volume value. These items are supposed to be monitored closely in order to catch any fluctuations in the demand pattern.

Shortage

Shortage are the items that are almost always ordered against customer order. Therefore, Alfa Laval's thoughts are that these items should have low, or no, safety stock. These have the most volatile demand pattern and are not ordered very often. This creates longer lead times for these items.

4.4 Quantitative Data

Quantitative data was gathered from Alfa Laval's database JEEVES in a number of fashions: through direct extraction, with the help of QlikView models, and using the tool ABC-Viewer. Excel was then used to format and handle the data. The following sections describe the various data that was gathered.

4.4.1 Data from Snapshot of Inventory

This data contains a snapshot view of information on an item level. Current performance, as well as the performance of proposed changes, can be evaluated using this data. In this way, iterative improvements upon parameters and item classification can be made.

About 2200 rows of data were collected and narrowed down to around 1600 rows after removing obsolete items, NPD articles, and internally produced items. There are many variables and fields in JEEVES that are unused and obsolete, therefore, the quantitative data needed to be sorted through to only get the information relevant. The collected data that was looked at contains information on the following for each individual item:

- Product number
- MAD, monthly basis
- Consumption over 12 months
- Cost
- MOQ
- Usage forecast over one year
- Previous ABC classification
- Order proposals per year

Forecast data is stored in the form of “Usage forecast 1 year” and was extracted on a monthly basis and divided by 12 to receive the forecasted demand for the following month. Order proposals are calculated based on forecasted yearly demand and EOQ or MOQ and currently amount to 7 918.

4.4.2 Historical Demand and Forecast Data

In order to evaluate the possibility of integrating demand forecasts in item classification, historical demand and forecast data was collected. The data includes monthly demand data for 12 months, counting from 6 months ago, as well as monthly forecasted demand for 1-6 months, starting from 6 months ago.

4.4.3 Sample Order Quotation

To allow for an analysis of quantity discounts, data on a sample order quotation of 20 items were gathered. The data was then transferred into Excel to examine the effect of quantity discounts on total costs and the EOQ.

4.5 Use of Empirics

The gathered empirics will be combined to create a comprehensive picture of the current situation and to answer the research questions of this thesis. The empirics relate to the research questions as shown in Figure 4.4.

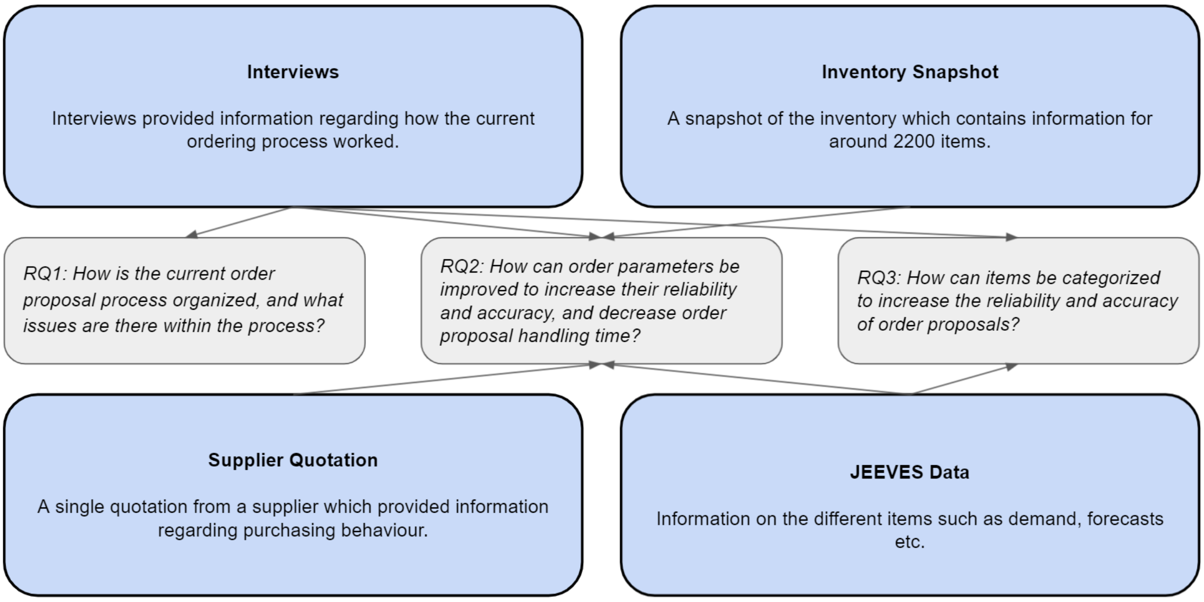


Figure 4.4: How empirics will be used to answer the research questions.

5 Analysis

The following chapter aims to analyze the empirical data, in order to answer the research questions of the thesis. This will be done with the help of ideas presented in the theory chapter as well as insights gained during the interviews. A brief summary of the current situation at Alfa Laval can be found in a SWOT analysis in Figure 5.1.

Strengths • Alfa Laval acknowledges existing issues, not in denial of problems • Plenty of data is captured, can be utilized for a more data-driven approach	**Weaknesses** • Lacks data-driven processes above individual evaluations • Lacks coherent strategy for the intersection of purchasing and inventory management
Opportunities • Utilize the expertise of employees with extensive experience • New employees excited to change and improve processes	**Threats** • Implementation of new ERP-system Dynamics drags on • Continued negligence of parameter and input upkeep aggravates existing problems

Figure 5.1: SWOT analysis of the current situation at purchasing within Alfa Laval.

5.1 Ordering Process

In the following section, other more qualitative aspects of improving the ordering process will be discussed. First, the current situation will be analyzed by examining the performed DILO, then the various purchasing styles, and lastly some other identified issues. Zooming in on the ordering process, the issues found in subprocess one and two are shown in Figure 5.2.

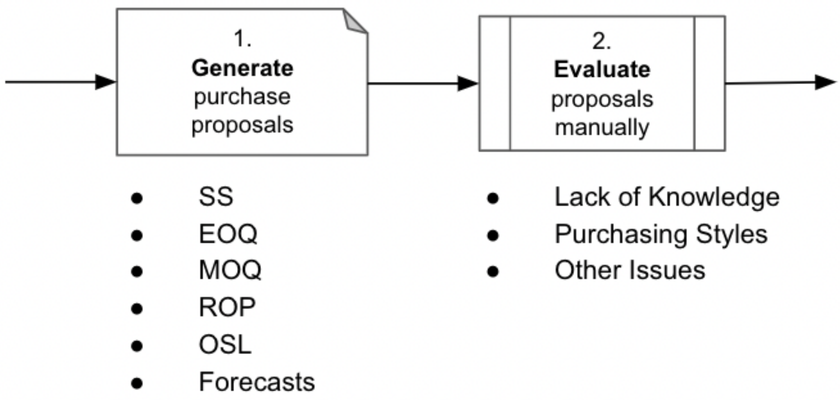


Figure 5.2: Issues found in subprocess one and two of the ordering process.

5.1.1 Purchasing Styles

One issue that was found when gathering the empirical data is that there are no objective criteria for what makes up an accurate order proposal. It is up to each purchaser and the purchasing style of that purchaser to determine if an order proposal is accurate. This means that the purchasing style of a purchaser can vary between two extremes, as presented in Purchasing Style A and B in Section 4.1.3.

The optimal purchasing style utilizes aspects from both of these styles for appropriate item classifications. It is clear that purchasing and inventory management must align their respective strategies, in order to reach the most efficient setup. The current setup leaves a lot of decisions to the individual purchaser, which is not optimal when trying to reach strategic goals. It does however empower purchasers and enables them to make their own decisions, which is useful for the cases where parameters must be questioned, and manual decisions are required.

The presented extremes are not desirable and are a result of a lack of guidelines. Ordering routines based around item classification should be developed, with the aim of removing any different purchasing styles and instead work towards a common goal throughout the organization. Active choices should be made to ensure that the appropriate kind of ordering routines is used for each type of item. This idea will be further elaborated on in the section on item classification, where guidelines for each classification will be provided.

5.1.2 Other Identified Issues

The items that Alfa Laval uses are spread over several different databases, seven in total. This makes it hard to get an overview of what items exist in what database, especially since there is no interface between them. It would be desirable to merge all databases into a single one to better be able to understand what items exist, and what the policy for each item is. This would also make it easier to implement changes in all departments at once and not one at a time, which is the case as of writing this thesis.

Another issue is that the interface and overview of JEEVES currently contains a large number of variables, parameters, and other fields that are not being used. This makes the interface appear cluttered and un-intuitive for newly employed purchasers, further increasing the time of the training period. It also adds to the confusion and lack of knowledge regarding parameters, as the sheer amount of them adds to the perceived difficulty of understanding relevant parameters.

5.2 Parameters

From the mapping of the ordering process, it was determined that subprocess two, evaluating proposals manually, is the most time-consuming. This is largely due to the fact that existing parameters are not utilized fully by the purchasers, and each item is instead investigated individually. The problem at hand is twofold: employees generally have lacking knowledge of how the system thinks or why a certain order is suggested, and parameters are inaccurate and unreliable. Therefore, both the question of whether the purchasers know how to interpret the parameters properly and the question of whether parameters are accurate will be addressed.

It is important to note that the restrictions of JEEVES, as well as the limitations of the data that Alfa Laval gathers, have been taken into account regarding what improvements are possible. The inaccuracy of parameters could be the result of them not being reviewed or updated for many years. Many of the parameters have not been changed since the implementation of JEEVES some 20 years ago. There are two main reasons as to why several parameters are old and unhelpful. First, the employees that created the current system have either stopped working at Alfa Laval or have been reassigned to different positions within the company. Second, Alfa Laval is trying to implement a new ERP system, Microsoft Dynamics, and therefore has lacking funding dedicated to implementing larger changes in JEEVES.

Improvements and updates made to parameters can however also be useful in the new ERP-system and should not be down-prioritized. In a world where the implementation of Dynamics would have gone flawlessly, the strategy of only focusing on the new system might have worked, but Alfa Laval is currently 8 years into implementation with a goal to finish the implementation in Lund during 2021.

5.2.1 Lack of Knowledge

In gathering the data, it became evident that employees in purchasing are lacking knowledge on how parameters should be used, and how the system thinks. This was evident both in individual interviews and from the sheer number of people input was collected to accurately map the ordering process and understand the different parameters and how they interact comprehensively. This lack of parameter knowledge leads to less informed decisions, more difficulty in deploying purchasing strategies, and more reliance on the experience of purchasers.

One example of lack of knowledge is a case where purchasers changed lead times for items. Problems arose when the supplier was having issues delivering at the set date. In some cases, the purchaser then changed the lead time of the supplier manually, which triggered the system to request even more materials. This created a feedback loop where the system requested more and more materials from the supplier who could not deliver on the orders, which delayed deliveries further.

This case also touches upon another identified issue: a lack of input ownership. There are many different inputs in JEEVES that are used for generating order proposals, and there needs to be someone that is responsible for making sure that they are correct. Currently, such ownership is lacking, and therefore the inputs, and in turn, the parameters, have been allowed to get more and more unhelpful as time goes on.

5.2.2 Safety Stock

The ABC classification that Alfa Laval currently uses for setting safety stocks is not coherent with other classifications throughout the organization. This leads to misaligned goals for inventory management and needs to be re-evaluated. Furthermore, as shown previously, both classifications A and B use the same SL of 98.2% which renders the ABC classification less useful, as only two classifications are in reality used. ABC classification could be a powerful tool to reduce inventory levels, as safety stocks according to demand data currently stand for around 2.2 months' worth of demand for each item. This is yet another example of the lack of a coherent strategy throughout purchasing and inventory management at Alfa Laval. In aligning the two departments, common goals regarding inventory levels could be set, and service levels could be determined accordingly.

One identified issue that could be a hindrance for this is that the data used for calculating MAD is not granular enough. Currently, MAD is calculated on a monthly basis, and it might be desirable to instead calculate it on a weekly, or even daily, basis. Problematically, the current ERP does not store data regarding weekly usage, so this value is impossible to calculate as of writing this thesis. However, with the aforementioned implementation of Microsoft Dynamics, this issue could be possible to solve.

Consider the worst-case scenario where an item is used in three-week intervals, which would give the monthly demand shown in Figure 5.3. This graph gives the impression that the usage is unstable with peaks every 3 months when, in fact, it is stable. This issue with too large granularity inflates the MAD by 44.4% of the difference in the peak months and the other months and, in turn, leads to 44.4% larger SS's than necessary. The CDV is calculated using the MAD, meaning that the item XYZ classification is also hampered.

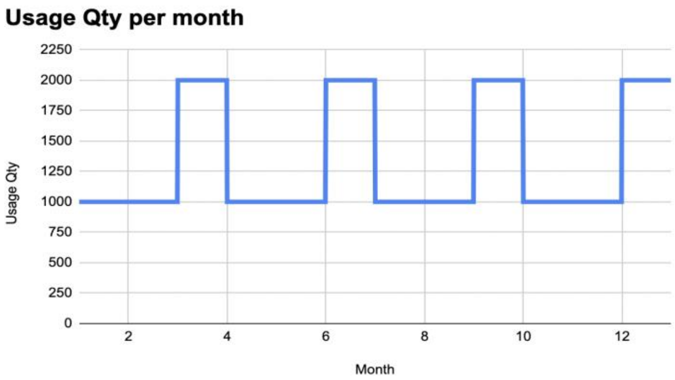


Figure 5.3: Example of a worst-case scenario for items used in three-week intervals.

Another factor to consider is that the SS parameter is used by JEEVES in determining whether orders should be proposed, and it is therefore extra important that it is accurate. If the SS parameter is inaccurate, JEEVES will not create order proposals at the right time, and the purchaser will not be aware of the fact that the item in question needs replenishment.

5.2.3 Economic Order Quantity

The EOQ is underutilized and inefficient in its current state. This is due to many purchasers deeming the parameter to be inaccurate and unreliable, and instead relying on experience when determining order quantity. As mentioned before, the reason behind this reprehension of using EOQ is the fact that it is not regularly modified and changed. Fixed numbers such as the order handling cost and inventory carrying cost have stayed constant since JEEVES was implemented around 20 years ago.

In reality, the order handling cost has gone up over the years, not least due to inflation. The ordering cost is commonly derived using an estimate, partly because it is hard to calculate precisely (Olhager, 2021), and partly because of the robustness of the EOQ model (Muckstadt & Sapra, 2010; Olhager, 2019). Some sources within Alfa Laval estimate the ordering cost to be up to 2 000 SEK, but the more modest estimate of 1 000 SEK will from here on be used. This estimate is confirmed to be reasonable by Olhager (2021).

The inventory carrying cost is more of a strategic number set by management as a way of valuing the opportunity cost of binding capital, interest on capital, and the cost of warehouse space. The current industry standard is around 15-20% of the product value (Olhager, 2021) and Alfa Laval's is set at 40%. This reflects the fact that Alfa Laval aims to reduce their inventory, and wants to make keeping inventory costly. To further increase the accuracy, one approach could be to change the carrying cost depending on what kind of item is being considered. This is however considered outside the scope of this thesis and will not be discussed in more detail.

If the EOQ suggested by Olhager (2019) is calculated for each individual item, it is possible to see how the total number of forecasted proposals per year changes with differing order handling costs. An increase in the ordering cost will lead to increased EOQs (Christoph, 2011), and therefore orders of larger quantities will be placed. This in turn leads to a decrease in the number of orders that need to be placed each year, as shown in Figure 5.4.

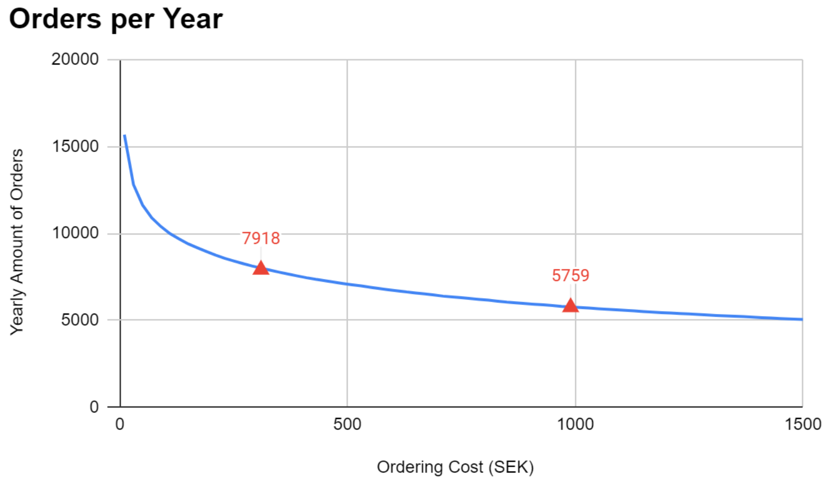


Figure 5.4: Total amount of forecasted order proposals per year as a function of the ordering cost. Current and suggested ordering cost is shown in red.

Examining the graph, one can see that a small amount of increase in ordering cost would lead to a larger decrease at first, with diminishing returns for larger ordering costs. The order handling cost is currently set to 325 SEK per order, giving a forecasted 7 918 order proposals per year, visualized by the left triangle in Figure x. Increasing the order handling cost to the suggested value of 1 000 SEK would instead yield a forecasted 5 759 order proposals per year, around two-thirds of the current number. By having fewer orders to process each year, the total time it would take to handle these would likely also decrease.

Increasing the EOQs would also theoretically lead to higher average inventory levels. However, purchasers do not currently follow EOQs strictly, which makes the actual effects of increasing the parameter hard to predict. Even if raising EOQs would lead to higher average inventory levels, Alfa Laval should aim for the parameters in use to be correct. Inventory levels should be managed in other ways, such as adjusting service levels of safety stocks or by setting an appropriate inventory carrying cost.

EOQ with Quantity Discount

A further expansion of the EOQ model is to include diminishing costs for purchasing larger quantities, increasing the accuracy of the EOQ parameter. There is currently a lack of data in JEEVES to perform this, as order quotations are handled by strategic purchasers manually. An example of how this can be done is given using sample data from an NPD order quotation, where 18 out of 20 articles had diminishing unit costs when purchasing larger quantities, most commonly with two breakoff points. On average, articles become around 44% cheaper when ordering the largest quantity, compared to the smallest quantity.

Olhager's (2013) model of quantity discount can be applied to an example item to see how it would affect the EOQ, resulting in Figure 5.5. The figure depicts an example of the total annual cost when ordering different quantities of an item. The item in the graph has an annual demand of 47 pieces, a MOQ of 4, and two breakoff points at 8 and 12 pieces. The top line is for order quantities between 4 and 8, the middle line is for quantities between 8 and 12, and the bottom line is for larger quantities. As seen in the graph, the bottom line gives the lowest cost but total cost increases for larger quantities. The EOQ can in this case be derived to 23 by comparing the minimum value of each segment.

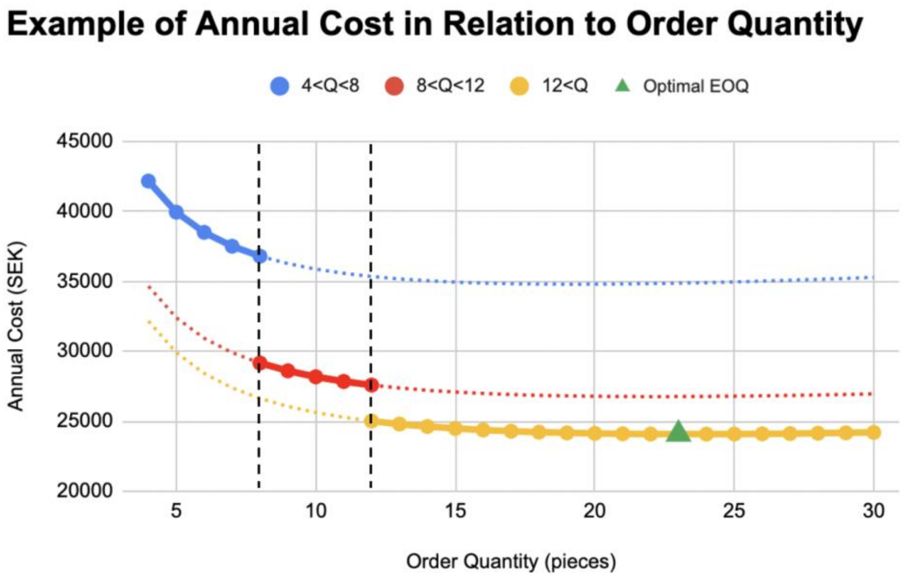


Figure 5.5: Example of the total annual purchase cost in relation to order quantity.

Currently, strategic purchasers make a judgment call on what order quantity is optimal, and the purchasing price is after that considered to be constant and independent from order quantity. Including diminishing costs in the EOQ model at Alfa Laval would make the process more data-driven and accurate. The EOQ could be calculated before signing contracts, resulting in less reliance on strategic purchasers' personal judgment.

5.2.4 Minimal Order Quantity

The MOQ of items has been considered an input to the system that cannot be affected, but it might be helpful to re-evaluate this. In some cases where the MOQ is far larger than the EOQ, this will have a large impact on inventory levels as optimal planning cannot be deployed. It is therefore proposed by the authors that a new parameter, comparative MOQ, is implemented, according to Equation 15. The need for such a parameter was determined from the quantitative data, where several items had large MOQs, as shown in Figure 5.6. This parameter could be reviewed in conjunction with re-evaluating item classifications, on a monthly basis.

$$Comp. MOQ = \frac{MOQ}{EOQ} \tag{15}$$

If the comparative MOQ is larger than two, the contract with the supplier should be re-evaluated to determine if new terms can be negotiated. The parameter would act as a red flag for items whose inventory management is heavily affected by their MOQ, which warrants an examination of the current supplier contract. In Figure 5.6, each staple representing the number of items equal to or below that comparative MOQ. The number of problematic items is reduced when increasing the ordering cost, but issues still exist. With ordering cost set to 1 000 SEK, 238 items, or about 14%, have a comparative MOQ of more than two. This could create problems with ordering since in cases where the MOQ is much larger than the EOQ, quantities that are not optimal are ordered.

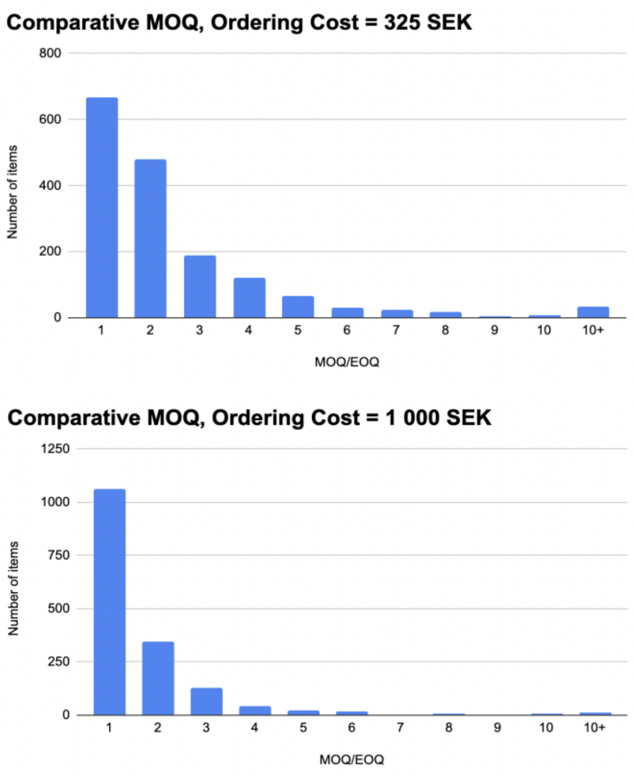


Figure 5.6: Comparative MOQ for all items, with current and proposed ordering costs.

5.2.5 Reorder Point

The system uses the reorder point that is in line with the previously discussed model proposed by Olhager (2019) and Muckstadt & Sapra (2010). The accuracy of the ROP depends on two factors, SS, and forecasted demand. Since forecasts at Alfa Laval are seen as reliable, the accuracy of the ROP largely depends on the accuracy of SS. Since SS is not completely up-to-date, purchasers do not trust the ROP fully and will often do a manual check and make their own judgment on whether or not the item needs to be restocked. This problem will be addressed by improving the SS parameter.

5.2.6 Optimal Stock Level

During the interviews, a general interest in determining the optimal stock level for different items was identified. The OSL is useful for purchasers in quickly judging the inventory level of an item, but it depends directly on SS and EOQ. As these parameters are not seen as correct, the OSL is not seen as correct either and is consequently not used, or used sparingly.

Furthermore, there is no company policy in place regarding what stock level should be seen as desirable or optimal. As described before, rather than working towards a common goal each purchaser has an individual responsibility to make sure that their items are available for production. By using the OSL, a purchaser can understand whether an item's inventory level is close to where it should be.

Using the previously calculated EOQs, it is possible to see how many items should be stocked in total using different ordering costs, as shown in Figure 5.7. In the figure, the aggregated amount of items that need to be stocked to achieve optimal stock level for all items is shown. Moreover, the triangles show the total OSL for the ordering costs 325 SEK and 1 000 SEK respectively.

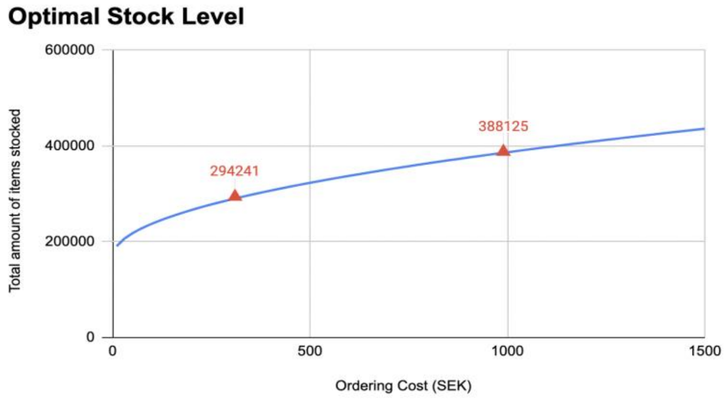


Figure 5.7: Total amount of items stored with different ordering costs, and EOQs.

As shown in the graph the higher the EOQ, the larger the OSL, with some diminishing returns. Under the assumption that the EOQ is too low for all items, one can see that the inventory stocked needs to increase. This could pose a problem since Alfa Laval is currently working to diminish their inventory and any suggestion to increase inventory may not be taken into serious consideration.

5.2.7 Forecasts

Forecasts can be performed in various ways, which is outside the scope of this thesis, and the focus will therefore be on the usage of the forecasts. While the unit level forecasts at Alfa Laval, known as SO99 forecasts, are considered to be fairly accurate for items in the standard assortment, there are some flaws in the way that forecasts are currently being used. Firstly, SO99 forecasts are performed on a unit level and there is no tool to translate them into JEEVES on an item level. Instead, the item forecast is created in JEEVES using historical data and several different analysis methods, and from this, each purchaser forms their own perception of the items they are responsible for. Optimally, the S099 forecasts should be able to be converted into a forecast on item level, since these forecasts are considered to be more accurate.

Furthermore, JEEVES is only able to handle forecasts on a 12-month basis. This creates problems since any change in use during the year, or seasonality, will not be taken into account. Table 5.1 shows how many weeks per year different items are used. This is not a perfect measure for variation of demand, but it is what Alfa Laval currently keeps a record of in terms of variation.

Table 5.1: The number of weeks items are used during a year.

Weeks Used per Year	Number of Items	% of Items
13 Weeks	581	35%
26 Weeks	364	22%
39 Weeks	262	16%
52 Weeks	440	27%

As seen in Table 5.1, there is a large variation between how often items are used, with 35% of items only being used 13 out of 52 weeks. Therefore, using a 12-month forecast creates a less accurate storage keeping policy for these items. This could lead to too much inventory being kept in stock during troughs in demand, and too little during peaks.

Even though the issue with the forecast horizon cannot be solved in JEEVES, the accuracy of the forecast could be increased by creating a tool to convert the unit level forecasts from SO99 into item level. However, this problem will be solved with the introduction of Microsoft Dynamic, since this ERP has the option of forecasting on different time horizons.

5.3 Item Classification

It is clear from the empirical data that a coherent strategy for item classifications needs to be implemented. The three-item categories identified by Alfa Laval: Batch, Proposal, and Shortage, can be used as guidelines, as they are based on the knowledge of experienced purchasers and inventory managers. The main issues that need to be dealt with regarding the division of items are the following:

- What criteria should be considered when classifying items?
- What should be the breakpoints for dividing items into classifications?
- How often should the classifications be updated?

The next question is where, and in what way, these classifications should be used. Factors such as how critical the process is for operations, how easy item classification would be to implement, and fit with Alfa Laval's systems were taken into consideration when deciding on the following areas:

- Safety stock
- Ordering routines
- Setting KPIs

First, the criteria for classifying items will be detailed. The next section elaborates on different application areas for the item classifications will be discussed. Finally, the possibility of integrating demand forecasting into the classification procedure is analyzed.

5.3.1 Classification Criteria

To divide items into the three identified categories it is proposed that an ABC-XYZ analysis mainly based on turnover, or volume value, and predictability, or the coefficient of demand variation (CDV), is used. This provides a methodical way of classifying items using data, and allows for regular updates to the classifications, while also taking the layout and limitations of the system at Alfa Laval into consideration. Item classifications need to be updated on at least a monthly basis, as they risk being incorrect if larger time periods are used (Scholz-Reiter et al., 2012).

ABC Classification

To divide the items into ABC classes, two different criteria has been identified as important to Alfa Laval, these are:

- Volume Value
- Yearly forecast in relation to MOQ

Volume value is a criterion that Alfa Laval already uses to classify their items, making it easier to translate into the new classification framework. This criterion is calculated by taking the used volume of an item each year and multiplying it with its cost. “A” items are the items that makeup 80% of the volume value. The value of these items was calculated for Alfa Laval, and the items follow the Pareto principle, as suggested by Stojanović & Regodić (2017) and Scholz-Reiter et. al (2012), closely. This criterion is therefore deemed as relevant and accurate for the purpose of splitting items into subclasses. The resulting distribution according to the Pareto principle can be seen in Table 5.2.

Table 5.2: Distribution of items according to the Pareto principle.

Volume Value	Top 80%	Next 15%	Last 5%
Number of Items	396	411	840
Percentage of Items	24%	25%	51%

The yearly forecast in relation to MOQ is the second criteria for creating ABC classifications. Having a larger quota between forecast and MOQ for an item means that a purchaser does not need to order a significant part of an entire year’s supply of that item at once. A lower quota means that large orders need to be placed, resulting in a larger average inventory level. Therefore, these items are found in either classification B or C. A summation of how the items were divided into the different ABC classifications can be found in Figure 5.8. The chosen limits between classifications were derived from interviews with purchasers and controllers and cross-referenced with quantitative data to ensure that a reasonable amount of items were placed in each classification. The resulting distribution is shown in Table 5.3.

Table 5.3: Distribution of items according to FC/MOQ.

FC/MOQ	> 8	2 < FC/MOQ < 8	< 2
Number of Items	524	610	513
Percentage of Items	32%	37%	31%

The combination of these distributions is used to create the ABC classes, according to the procedure in Figure 5.8.

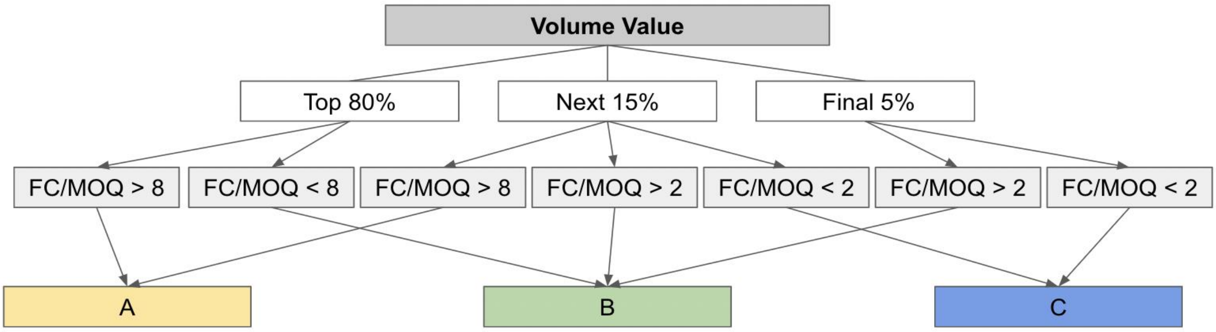


Figure 5.8: Classification of items into ABC classes.

The final division of ABC classifications after combining volume value and the yearly forecast in relation to MOQ can be found in Table 5.4.

Table 5.4: Final number of items in each ABC classification and their percentage of the total value.

Classification	A	B	C
Number of Items	344	823	480
Percentage of Items	21%	50%	29%
Percentage of Total Value	57%	39%	4%

XYZ Classification

The XYZ classification aims to incorporate predictability of demand by using the CDV of individual items. A higher CDV means a more unpredictable demand and a lower CDV indicates a more stable demand. By using this criterion, it is possible to understand what orders of items can be purchased without a more thorough individual analysis. However, the breakpoints for determining what classification items should receive depends on the specific context and needs to be set manually.

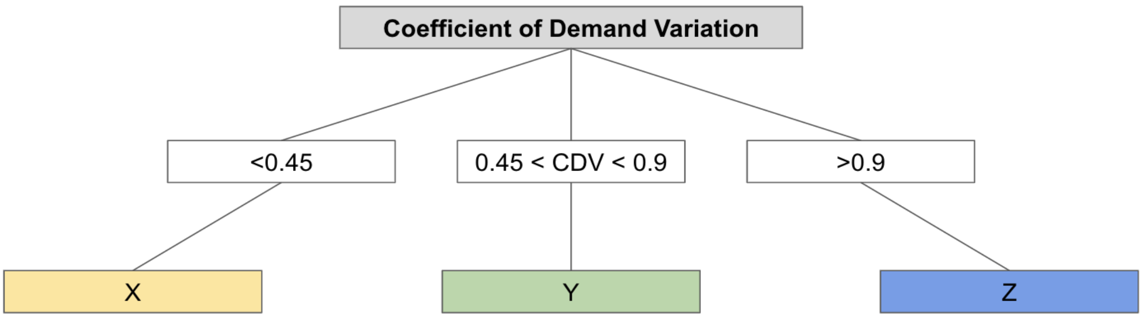


Figure 5.9: Classification of items into XYZ classes.

As shown in Figure 5.9, items are divided up in accordance with their CDV, with limits set at [<0,45; 0,45<X<0,9; >0,9] for classifications [X; Y; Z], respectively. As previously stated, items with a lower CDV have a more stable demand and are therefore placed in classification X, while items with a higher CDV have a more unpredictable demand and are therefore placed in classification Z, with the in-between items ending up in classification Y. The limits were chosen using Scholz-Reiter et al.'s (2012) suggestion for three categories, in combination with Wanke & Zinn's (2004) finding that items with a CDV of 0,9 or greater should always be PTS. This will be further elaborated on in the section on the usage of item classifications in ordering routines. The middle limit was then adjusted to 0,45 to make the boundaries evenly divided. The resulting division from this classification can be found in Table 5.5.

Table 5.5: Number and percentage of items in each XYZ classification.

Classification	**X**	**Y**	**Z**
Number of Items	366	618	663
Percentage of Total	22%	38%	40%

Translation from ABC-XYZ to Proposal, Batch, and Shortage

These two classifications are then combined to form the ABC-XYZ classifications which then indicates whether an item belongs to the proposal, batch, or shortage category. The translation from ABC-XYZ classifications to Proposal, Batch, and Shortage is shown in Table 5.6.

Table 5.6: Translation from ABC-XYZ classifications to the proposed item categories.

	A (high)	**B (average)**	**C (low)**
X (high)	Proposal	Proposal	Batch
Y (average)	Proposal	Batch	Shortage
Z (low)	Batch	Shortage	Shortage

As discussed by Stojanović & Regodić (2017), classes AX, BX, and AY are most appropriate for JIT approaches and are therefore chosen as the *Proposal* category at Alfa Laval. Classes AZ, BY, and CX are consequently considered to fit well with the characteristics of *Batch* and classes BZ, CY, and CZ with *Shortage*. Using this division, the percentage of items in each group can be seen in Table 5.7.

Table 5.7: Distribution of items in the different classes.

	A (high)	B (average)	C (low)
X (high)	9.0%	10.4%	2.8%
Y (average)	9.3%	19.9%	8.4%
Z (low)	2.6%	19.7%	17.9%

The distribution in Table 5.7 translates into the three categories according to Table 5.8. As both tables show, a reasonable amount of items are placed in each classification and thereafter category, confirming that the chosen limits are feasible.

Table 5.8: Number of items in each category.

	Proposal	Batch	Shortage
Items	472	417	758
Percentage of Total Items	29%	25%	46%

5.3.2 Usage of Item Categories in Ordering Routines

Item categories can be used in creating ordering routines, where each category is to be approached in a certain way. By setting guidelines for each category, an approach tailored to each categories' characteristics can be employed. A summary of the approaches can be seen in Table 5.9.

Proposal

As stated before, items in the Proposal classification are characterized by steady demand, large volume value, and a small MOQ in relation to a yearly forecast. These characteristics all lend themselves well to order according to proposals from JEEVES without too much hesitation, individual investigation, and analysis.

Batch

Batch items are harder to categorize due to their more unstable demand. Because of this, and their volume value still being quite large, it is suggested that these order proposals require more manual effort to be put towards handling them.

Shortage

Shortage items generally have a very fluctuating demand, a low volume value, and a large MOQ in relation to a yearly forecast. This means that SS would need to be very high to guarantee a high service level, which is expensive. These items are therefore PTO and only ordered upon customer request.

Table 5.9: Summary of proposed ordering routines for each item classification.

Category	PTS/PTO	Manual Handling	Approach
Proposal	PTS	Low	Order the EOQ/MOQ amount when proposed by JEEVES
Batch	PTS	High	Order larger quantities rely more on own analysis
Shortage	PTO	Low	Order EOQ/MOQ upon customer request

Table 5.10 shows how many proposals each category contains. Using the suggested approach, the proposals that a purchaser mainly needs to analyze are therefore the proposals under the Batch category, making up 24.6% of total order proposals. Order proposals under the Proposal category, making up 51.5%, can be placed without much manual labor, and Shortage items, making up 23.8%, are ordered only at customer request. Due to time limitations, only an assumption on how much time will be saved from these changes will be provided. If it is assumed that time spent manually handling items in the Proposal and Shortage categories are reduced anywhere between 25% and 60%, the total time spent on handling order proposals can be calculated as shown in Equation 16. The time spent will then be reduced anywhere between 19% and 45%, in a linear fashion. A further investigation into how big this time saving is will have to be carried out at a later date by Alfa Laval.

$$1 - \big((0.246 + 0.515) \cdot t + 0.238\big) = \ time\ saved \qquad (16)$$

Table 5.10: Number of proposals in each category.

	Proposal	Batch	Shortage
Proposals per Year	2967	1419	1373
Percentage of Proposals	51.5%	24.6%	23.8%

5.3.3 Usage of Item Categories in Setting SSs

SSs are, as previously mentioned, an area of interest for lowering average inventory levels. One way of doing this is by using item categories and setting different SLs, and thereby safety factors, for different categories. In this way, it is possible to maintain high SLs for items identified as critical while reducing the average level of SSs. The following analysis uses the number of items as an indicator of how large the SS is and will be. This is not a perfect measurement as other factors such as size and "stackability" matter, but these measures are currently not recorded by Alfa Laval.

The authors aim to choose SL, and thereby safety factors, that results in the same average inventory as Alfa Laval currently has since the goal of this thesis is not to reduce inventory levels, but rather to make the ordering process more efficient. This is further discussed in Section 5.4. Table 5.11 shows the number of items in each category, the chosen SLs, related safety factors, and the resulting amount of items in SSs for each category. Batch items receive a lower SL as they will be ordered in larger quantities, meaning that the average inventory will be higher. Shortage items will be PTO and are therefore not stocked, which means that SS equals zero for these items. The safety factors related to each SL are adapted from Olhager (2019) and Axäter (2006).

Table 5.11: Proposed SLs and related safety factors, and resulting items in SS for new item categories.

Category	Number of items	Service Level	Safety Factor	Items in SS
Proposal	472	97.5%	1.96	98 280
Batch	416	75%	0.67	13 994
Shortage	758	-	-	0

From the quantitative data, we can conclude that the current inventory has 170 662 items in SS, using ABC classifications with 98.2%, 98.2%, and 95.1% SL respectively. The chosen SLs will result in a total safety stock of 112 274 items. This means that the proposed changes will reduce the SS by 56 702 items, meaning about 34% less than the current setup.

5.3.4 Usage of Item Categories in KPIs

The proposed item categories can further be utilized when setting KPIs for purchasing. The existing KPIs are broad and hard to utilize for the day-to-day work of an individual purchaser. Every attempt to translate these KPIs into more useful measures is therefore useful. By using item categories more specific goals for KPIs can be set, which is useful since characteristics vary greatly between the categories. The proposed use of item categories for setting KPI goals is presented in Table 5.12.

Table 5.12: KPIs at Alfa Laval, with the proposed use of item categories.

KPI	**Use of Item Categories**
OP F&E	Proposal and Batch items should have higher goals for creating profit, while Shortage items mostly provide a broader assortment.
OFLTd	Proposal and Batch items should have higher requirements to meet desired lead times. Shortage items are PTO and customers must accept longer lead times.
IDS	Proposal and Batch items should have an acceptable level of IDS, while the goal for Shortage items should be to have as few IDS as possible.

It is however important to note that the existing KPIs are not optimal and need to be reevaluated. They are set on a factory level and need to be more specific to be helpful for purchasers. Using item categories is a step in the right direction but does not fully address all issues with the existing KPIs.

5.3.5 Integration of Demand Forecasts in Item Classification

To increase the accuracy of the item classification at Alfa Laval it is proposed that demand forecasts are integrated into the classification process in the manner described by Scholz-Reiter et al. (2012). In doing this, future trends are taken into account, making item classifications truer to reality. This is a good fit for Alfa Laval since their forecasts are considered to be accurate, especially if they are able to break down SO99 forecasts to an item level, which the new ERP-system Dynamics is planned to do. The method presented by Scholz-Reiter et al. (2012) also offers quantifiable advantages in making the classification process more accurate.

The procedure of integrating demand forecasts will now be gone through step-by-step. The current setup at Alfa Laval uses 12 months of historical consumption data and will be used as the past classification shown in Figure 5.10(c). Classifications 1-6 in Figure 5.10(b) are then compared with the past classification in terms of correspondence with the reference classification, shown in Figure 5.10(a). It is important to note that the data set used for this comparison does not include the full range of items previously used since historical demand data and forecasts could not be extracted for all items. This results in a slight deviation from the previous distribution of items in classifications but does not affect the conclusions drawn from this section. The distributions for all the classifications can be found in Appendix E.

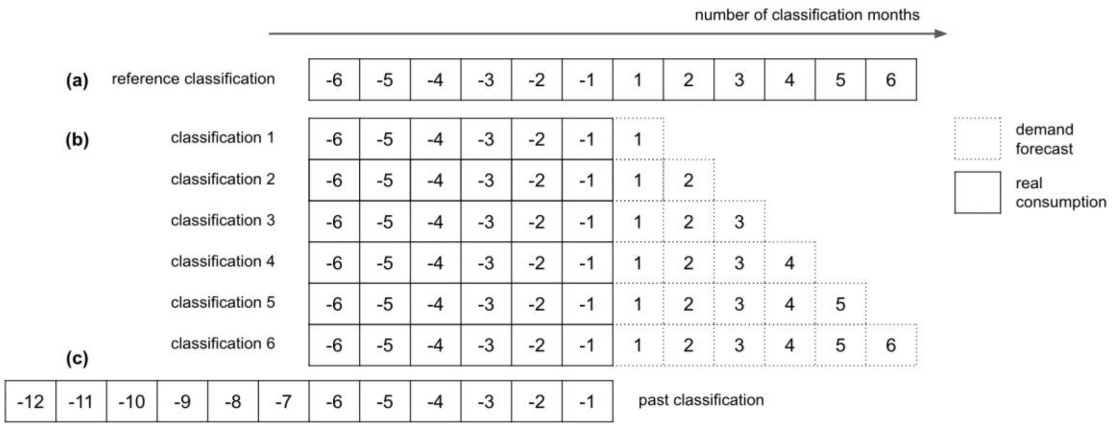


Figure 5.10: Data used for the reference classification, test classification, and past classification.

Creating a Reference Classification

First, a reference classification is created using real consumption data only, as shown in Figure 5.10(a). The resulting distribution is considered the optimal distribution of items over the examined period of 12 months.

Creating Classifications 1-6

Next, classifications 1-6, presented in Figure 5.10(b), are created using 6 months of real consumption data and 1-6 months of demand forecast data, from that point in time. The demand forecast data was used in the calculation of volume value as well as CDV, meaning that both ABC and XYZ classifications were affected.

Creating the Past Classification

The past classification, shown in Figure 5.10(c), uses 12 months of real consumption data and reflects Alfa Laval's current way of classifying items. This classification can be viewed as a baseline to compare classification 1-6 with, to see if any improvements are made.

Comparing the Resulting Distributions

Figure 5.11 compares the distributions from the past classifications and classifications 1-6 in terms of correspondence with the reference classification. As shown, Class 1, integrating 1 month of forecasted demand, gives the highest correspondence with the reference classification and thereby the optimal result. The past classification corresponds to 69% with the reference classification, and we can derive that integrating 1 month of forecasted demand gives 3% better classification results than the past classification.

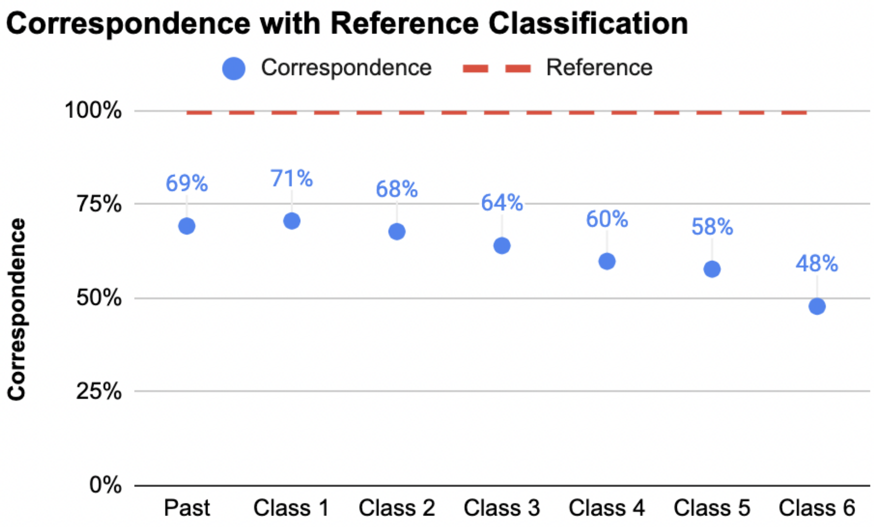


Figure 5.11: Correspondence of the past classification and classification 1-6 with the reference classification.

This small improvement was made using the demand forecast currently used by JEEVES and does not involve the more accurate forecast performed by SO99. The resulting improvements for item classification are promising and integrating SO99 forecasts would most probably result in more months of forecast data being used. This further development of the item classification process should therefore be considered in the future when Microsoft Dynamics is implemented, and more accurate forecasts can be used.

5.4 Effects of Proposed Changes on Storage

Due to the nature of some of the changes proposed, the amount of inventory in storage will increase. However, SS will, as previously mentioned, be reduced by 34% which will dampen the effects of this increase in storage. Because an outspoken goal of Alfa Laval is to lower the amount of inventory in storage, the SLs were set with this in mind and adjusted to make sure that the OSL did not increase markedly. The result of this can be seen in Figure 5.12, where the triangles are OSL before and the squares are after including changes to the SS.

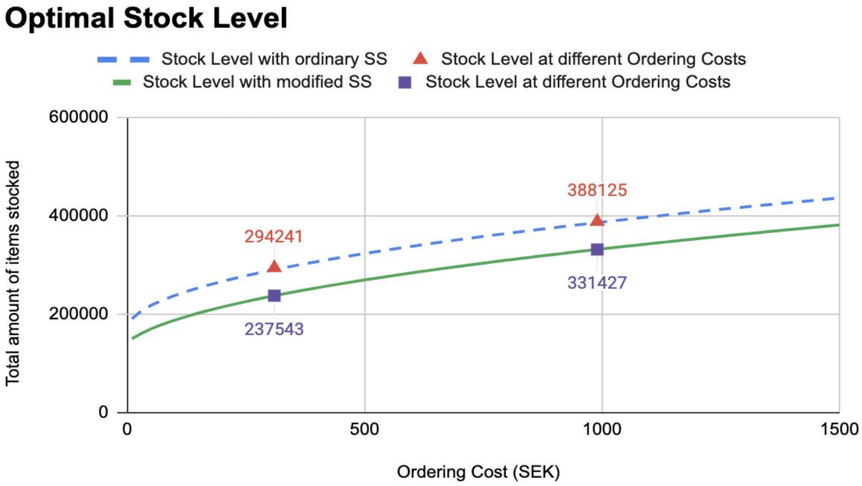


Figure 5.12: Effects of proposed changes on inventory levels.

It is also important to note that since purchasers do not currently follow EOQ's strictly, the actual OSL is most likely larger than the theoretical value. The theoretical increases of 11% in OSL shown in Figure 5.12 might therefore not result in a real increase of inventory levels. This will have to be monitored when changes are implemented, and SL's can iteratively be adjusted to ensure that the desired stock level is reached.

6 Conclusion

This chapter concludes the thesis by answering the research questions, summarizing the findings, and providing recommendations for Alfa Laval moving forward. A discussion on how to generalize the findings is also provided, as well as suggestions for further developments of the results and future studies.

6.1 How is the current order proposal process organized, and what issues are there within the process?

The mapping, as shown in Figure 6.1, describes how the current order proposal process is organized. Each subprocess is described in greater detail in section 4.1.1.

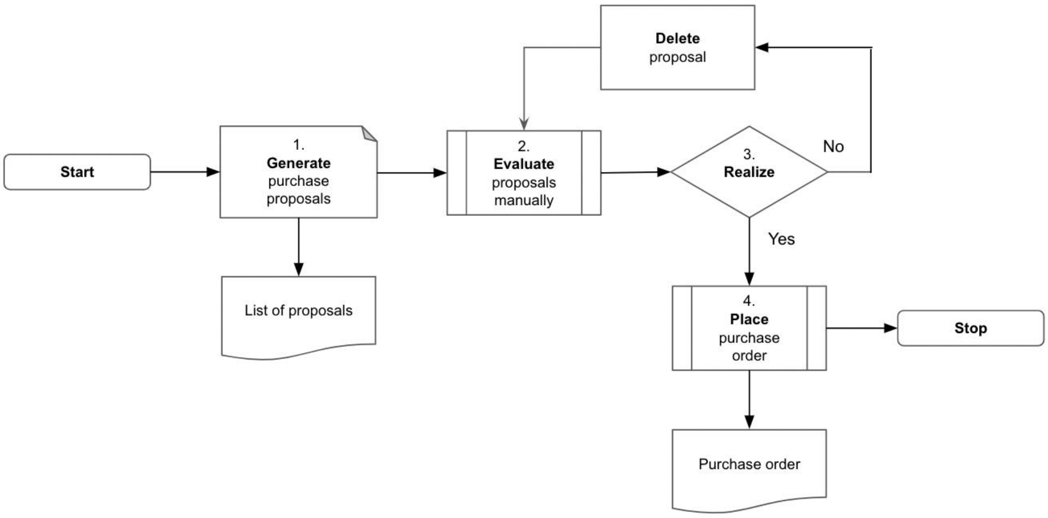


Figure 6.1: Process map of the ordering process at Alfa Laval.

The process was evaluated to have several weaknesses and areas where it could be improved upon, these can be found in Figure 6.2.

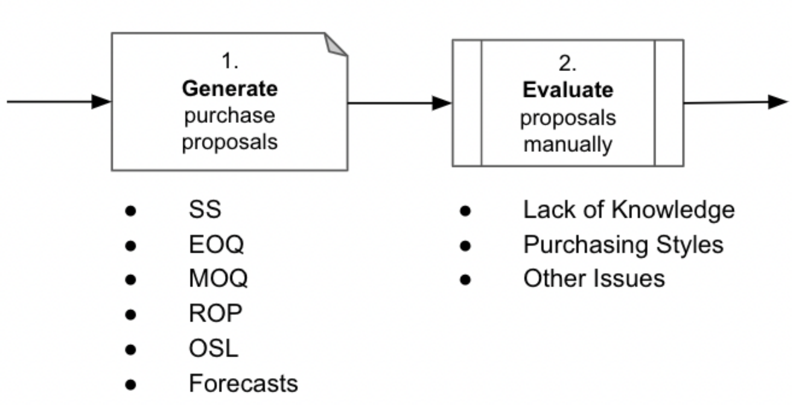


Figure 6.2: Issues found in subprocess one and two of the ordering process.

In general, the order proposal system is subject to a lack of accountability and responsibility regarding updating and keeping parameters and routines up-to-date and relevant. A deeper understanding and knowledge among the purchasers as to how the ERP system works and what the parameters are based on is found to be lacking. Moreover, the lack of guidelines has led to purchasers developing their own styles of purchasing, making inventory management more difficult as well as making objectively good order proposals more ambiguous.

6.2 How can order parameters be improved to increase their reliability and accuracy, and decrease order proposal handling time?

In general, the parameters were found to be outdated and lacking in usefulness. For the purchasers to start using the parameters as intended, the changes below are suggested to be implemented.

6.2.1 Safety Stock

The current setup at Alfa Laval sets two different SLs for items according to an ABC analysis based on volume value. This is not coherent throughout other calculations and should be aligned to increase consistency. Another issue is the granularity of the data used for calculations, which can lead to incorrect safety stock levels. In the worst-case scenario, this can lead to over 40% larger SSs for items. There is currently no easy fix to this problem, but it should be taken into consideration when implementing Microsoft Dynamics.

It is proposed that SLs are adapted to better fit the characteristics of the proposed item categorizations Proposal, Batch, and Shortage. The SLs shown in Table 6.1 were developed iteratively with the goal of keeping inventory levels equal combined with other proposed changes but needs to be revised continuously after implementation.

Table 6.1: Proposed SLs and related safety factors.

Category	Service Level	Safety Factor
Proposal	97.5%	1.96
Batch	75%	0.67
Shortage	-	-

6.2.2 EOQ

The EOQ is currently viewed as unreliable, leading to purchasers relying more on experience than metrics. The main reason behind this is that the ordering cost variable has not been updated in around 20 years. A new ordering cost is estimated to 1 000 SEK in this thesis, based on interviews with employees at Alfa Laval and confirmed by Olhager (2021).

Increasing the ordering cost, and thereby the EOQs will lead to fewer order proposals each year, as order quantities get larger. The proposed update reduces the number of order proposals per year from around 7 900 to around 5 800, which would also most likely increase the accuracy of the remaining order proposals. Another effect of increasing EOQs is that the theoretical stock levels will increase, which might be undesirable. Alfa Laval should however strive to have an accurate ordering cost, and inventory levels should be controlled in other ways, for example by adjusting SLs or the inventory carrying cost.

6.2.3 MOQ

The MOQ is currently set by strategic purchasers before the start of the ordering process, which in some cases leads to a far larger MOQ than what is economically optimal, ordering the EOQ. It is therefore proposed that a new parameter, comparative MOQ, is implemented. The comparative MOQ equals the MOQ divided by the EOQ and is an indicator of whether the MOQ needs to be re-evaluated. With an ordering cost of 1 000 SEK, about 14% of items have a comparative MOQ of greater than two, which means that the MOQ of these items should be examined.

6.2.4 Forecasts

While the actual forecasts and the related methods are considered outside the scope of this thesis, a number of issues concerning the usage of forecasts were found. JEEVES currently performs yearly demand forecasts on an item level, which fails to include possible variations in demand over the year and seasonality. Further, 35% of items are only used a quarter of the weeks of a year, which indicates that a large variation of demand exists.

When implementing Microsoft Dynamics, it is therefore proposed that SO99 forecasts are translated into item level, to increase the accuracy of item level forecasts. This will in turn make parameters such as SS, EOQ, OSL, and ROP more accurate, leading to more accurate and reliable order proposals.

6.3 How can items be categorized to increase the reliability and accuracy of order proposals?

As Alfa Laval currently does not have a coherent way of categorizing their inventory throughout the organization, an ABC-XYZ analysis based on volume-value and coefficient of demand variability is suggested to understand what items are important and stable, and which are less important and unstable. It is recommended that these categories are updated monthly, to ensure that items are placed in the correct category.

6.3.1 ABC Classification

The ABC classification is based upon volume value, which is a common practice within the industry. The Pareto principle in combination with the Forecast over MOQ is used to determine what ABC-class the item is placed into according to Figure 6.3.

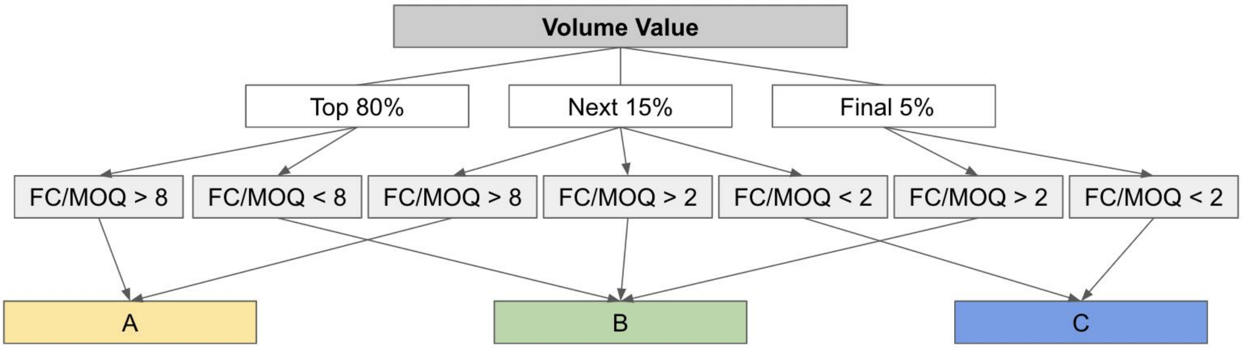


Figure 6.3: Classification of items into ABC classes.

6.3.2 XYZ Classification

With the XYZ classification, the aim is to incorporate the variability of demand into the analysis. This is done by using the coefficient of demand variability and classing the items with differing variability into different classes. The classes and how they were divided can be seen in Figure 6.4.

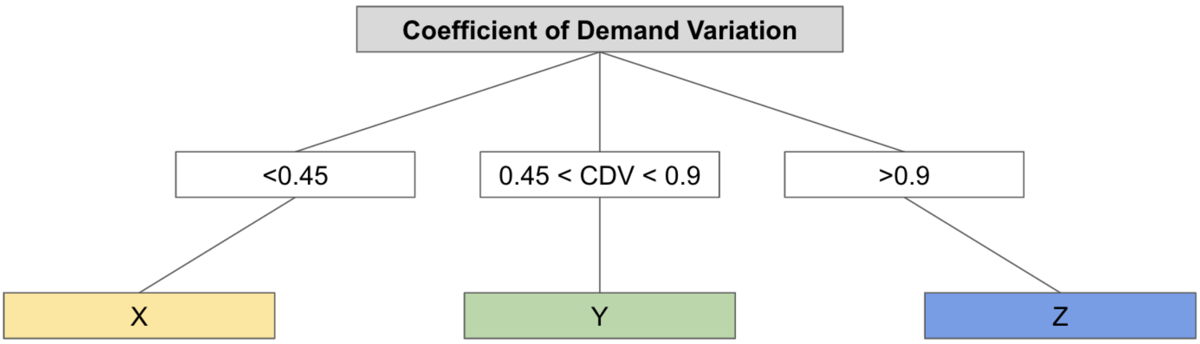


Figure 6.4: Classification of items into XYZ classes.

6.3.3 Resulting Categories

Table 6.2 shows the number of items that were assigned to each class with the aforementioned process.

Table 6.2: Distribution of items in the different classes.

	A (high)	**B (average)**	**C (low)**
X (high)	9.0%	10.4%	2.8%
Y (average)	9.3%	19.9%	8.4%
Z (low)	2.6%	19.7%	17.9%

In order to create guidelines that are easy to follow, these 9 classes were further divided into 3 categories already familiar at the company: Proposal, Batch, and Shortage. Proposal represent the items that are very stable and have a high volume-value as well as a low MOQ in relation to its forecast, Batch represents the items that are quite unstable and a lower volume-value than the Proposal items and Shortage represents the most unstable and least valuable items. The division of classes into each category can be seen in Table 6.3.

Table 6.3: Translation from ABC-XYZ classifications to the proposed item categories.

	A (high)	**B (average)**	**C (low)**
X (high)	Proposal	Proposal	Batch
Y (average)	Proposal	Batch	Shortage
Z (low)	Batch	Shortage	Shortage

The resulting amount of items in each of the three categories can be seen in Table 6.4.

Table 6.4: Number of items in each category, using a sample of 1647 items.

	Proposal	**Batch**	**Shortage**
Items	472	417	758
Percentage of Total Items	29%	25%	46%

6.3.4 Ordering Routines for Categories

Due to the categories having items with different characteristics, the process of handling the order proposals from the different categories is different. The suggested approaches to the different classes can be seen in Table 6.5.

Table 6.5: Summary of proposed ordering routines for each item classification.

Category	PTS/PTO	Manual Handling	Approach
Proposal	PTS	Low	Order the EOQ/MOQ amount when proposed by JEEVES
Batch	PTS	High	Order larger quantities and rely more on own analysis
Shortage	PTO	Low	Order EOQ/MOQ upon customer request

6.4 Effect on Order Proposals

With the proposed changes to the parameters, the total amount of proposals would decrease from 7 918 to 5 759, a percentual decrease of 27% which can be seen in Table 6.6.

Table 6.6: Changes in proposals before and after parameter change.

	Before Parameter Change	After Parameter Change
Proposals	7 918	5 759

By implementing the presented item categories and their suggested ordering routines, the time spent handling order proposals can be reduced further. In Table 6.7, a summary of the amount of proposals in each category and their suggested handling is presented.

Table 6.7: Effects on amount of proposals by implementing categories.

	Proposal	Batch	Shortage
Proposals per Year	2967	1419	1373
Percentage of Proposals	51.5%	24.6%	23.8%
Manual Handling	Low	High	Low

If it is assumed that the time spent on handling order proposals is reduced by at least 50% in the Proposal and Shortage categories, the total time savings would then be 38% compared with the current setup.

6.5 Summary of Recommendations

The conclusions drawn from the analysis are summarized into a number of recommendations in Table 6.8. These should be viewed as the authors' opinions as to what proposed changes are most important but do not cover all suggestions made throughout the thesis.

Table 6.8: Summary of the most important recommendations made in this thesis.

Area	**Recommendation**	**Effect**
Parameters	Update Safety Stock and EOQ, implement Comparative MOQ.	More reliable and accurate order proposals, less time spent handling order proposals, as well as an indicator for high MOQs.
Item Classification	Create three item categories based on ABC-XYZ analysis. Use in Safety Stock, KPIs, and ordering routines.	More accurate item classifications, and better use of them. This leads to more effective inventory management, and less time spent on order proposals.
Ordering Process	Create ordering routines and increase knowledge of parameters.	Less reliance on purchasers' experience and more on objective goals.

6.6 Generalization of the Results

The conclusions and recommendations of this report are somewhat applicable in other departments at the factory in Lund, but also in other Alfa Laval factories in different countries and markets. By using a similar approach throughout Alfa Laval, stringency will increase, and it will become possible to benchmark and compare KPIs between departments. A similar approach to mapping processes as the one used in this thesis can be used to identify and manage differences in the specific context in question.

The suggested improvements for parameters and item classifications do not take into account what type of item is concerned, which makes the findings generalizable to other Alfa Laval sites and other companies which are similar to Alfa Laval. It is also probable that the other identified issues in the ordering process at LA can be found in other departments or at similar companies.

Lastly, since the ERP system JEEVES is used in other companies in Sweden, the improvement opportunities found in this thesis could be of benefit of developers and users of JEEVES. The team at JEEVES could get a greater understanding of why Alfa Laval choses to switch to Microsoft Dynamics and therefore prevent other companies from doing similar switches.

6.7 Practical and Theoretical Contribution

This thesis has been conducted as a case study, with the aim of mapping and improving the ordering process at Alfa Laval. The results should therefore be a great practical contribution, and the recommendations should all be considered for implementation. As the implementation part has not been considered, further cost and benefit analyses is needed to determine how to move forward. The recommendations have been made with the current ERP-system JEEVES in mind but whenever possible, consideration of the future implementation of Microsoft Dynamics have been taken.

As for theoretical contribution, the conclusions of this thesis are highly context dependent and can be hard to generalize. As the discussion under section 6.6 states similar contexts at Alfa Laval or similar companies can benefit from the conclusions made in this thesis. Further, as there is currently not a lot of research on the operational part of the ordering process, this thesis can be used for inspiration of future case studies. The approach used to map out the ordering process, as well as improve upon identified issues, could be useful as a guide for other researchers in streamlining the ordering process.

6.8 Concluding Remarks

To conclude this thesis, the following section will contain some observations of subjects that were only touched upon briefly in the analysis or that have a potential for future studies.

6.8.1 Future Areas of Interest

There are two main areas that are found to be of interest in the future for Alfa Laval; the use of quantity discounts in the EOQ and the integration of demand forecast into classifications of items. For both, there is a need from Alfa Laval's side to gather better and more relevant data.

Quantity Discounts in the EOQ

The volume discount could be a powerful tool to use when understanding what quantities of units are economic to order and which are not, especially when handling orders that have a large MOQ compared to the forecast. By using the comparative MOQ, the number of items that this could be relevant for can be said to be around 14% of the total amount of items. Since the current EOQ calculation does not use discounts of any sort, it is hard to predict how the EOQ would change by using discounts in the calculations.

Integration of Demand Forecasts in Item Classification

By integrating demand forecasts into both ABC and XYZ classifications, future trends are taken into account, making item classifications truer to reality. Class 1-6, in Figure 6.5, was created using 6 months of historical data and 1-6 months of forecasted demand, and compared to the past classification, which uses 12 months of historical data. Using the current, somewhat crude, forecast a higher correspondence compared to the past setup was found for Class 1, using one month of forecasted demand, which gives around 3% better correspondence with the reference classification. The result is promising and if better item level forecasts are made a reality, using this method can further increase the accuracy of the item classification process.

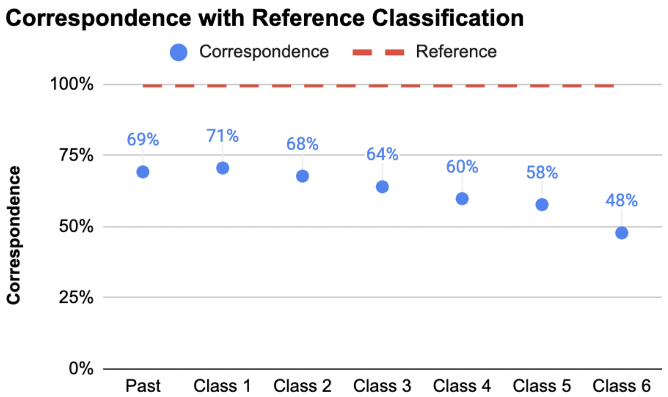


Figure 6.5: Correspondence of the past classification and classification 1-6 with the reference classification.

6.8.2 Future Studies

The following areas are recommended for future studies but have for one or another reason not been further investigated by the authors.

Updating the Carrying Cost

The carrying cost in the EOQ calculations were not further investigated, as this was stated to be a strategic value set by management. However, it has not either been updated in around 20 years which calls for an investigation.

Communication Between Departments

The manner in which the purchasing department communicates with strategic purchasers and inventory controllers is another area fit for future studies. Some discrepancies were found regarding this communication, and further investigation is recommended to align the departments.

Updating KPIs for the Purchasing Department

The current KPIs are broad, entail more than just the work of the purchasing department, and are hard to relate to for an individual purchaser. An area of interest is therefore to set more relevant KPIs, not just for the purchasing department but for all departments at LA.

Correct Item to Correct Purchaser

In this thesis, the parameters and groupings of items have been studied and analyzed. The next step is to determine how to distribute the items among the purchasers and how to structure the categorization of the items within JEEVES. As understood from the interviews, GCC has had some projects in this area and LA could take some inspiration as to how they use JEEVES to categories the items and how they split the items among the purchasers.

Optimal Stock Level

Alfa Laval lacks policies that decides what stock level is desirable. The only measure that they use is the somewhat crude OSL, which in this thesis will be increased. A future thesis or improvement project on the subject could therefore be of use to understand how the different factors influence the stock level and what parameters should be used when deciding and controlling how much is in storage.

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Appendices

Appendix A. Unstructured Interview Guide

Roles interviewed:

Supply Chain Manager, LA
Purchasing Manager, LA Source
Purchaser 1, LA Source
Purchaser 2, LA Source
Project Manager, GCC

Interview Guide

1. What is your role at Alfa Laval, and what are your responsibilities?
2. Can you describe the ordering process and the related activities?
3. Can you describe the subprocesses in more detail?
4. What determines if an order proposal is proposed by the current system?
5. How does a purchaser determine whether or not to realize an order proposal?
6. What do you believe are the main reasons that the order proposals are lacking in accuracy and reliability?
7. What potential improvement areas do you see in the ordering process?

Appendix B. Semi-Structured Interview Guide - Purchaser

Interview Guide:

1. What is your role at Alfa Laval, and what are your responsibilities?
2. In what way do you use the various parameters when ordering items?
    a. Safety Stock
    b. ROP
    c. EOQ
    d. MOQ
    e. Forecasts
3. Please describe the Proposal/Batch/Shortage categories.
4. What KPIs does the purchasing department have?
    a. How do you use them?
5. Are there any common guidelines for ordering items?
    a. If not, what is your personal approach?
6. What is your reasoning when ordering
7. Do you have any input on our proposition regarding ABC-XYZ classification?

Appendix C. Semi-Structured Interview Guide - System Support

Interview Guide:

1. What is your role at Alfa Laval, and what are your responsibilities?
2. What is the logic behind how the system creates an order proposal?
    a. Can you explain the reasoning behind using REPL_ALL instead of REPL_LT?
3. Are there any unnecessary variables that are not used?
4. It seems like a lot of old products are left in the system, do you know why?
5. We've examined the parameters in JEEVES and are wondering about the details of:
    a. SSL vl
    b. SSdays
    c. LTDays
    d. x in the ABC column
6. We're also curious about how the following parameters are calculated:
    a. Order Point
    b. SSL vl (Safety Stock Level)
    c. EOQ
    d. UseForecast
    e. LTDays
7. Is it possible to find MOQs in JEEVES?
8. Is it possible for us to add new variables into JEEVES?

Appendix D. Semi-Structured Interview Guide - Supply Planner GCC and Master Planner GCC

Interview Guide:

1. What is your role at Alfa Laval, and what are your responsibilities?
2. Can you explain how safety stocks are calculated?
    a. Are there different methods for different items?
    b. Can we access the tool?
3. Can you describe how the following parameters are calculated and used?
    a. EOQ
        i. Carrying Cost
        ii. Ordering Cost
    b. SSL
        i. How were the service levels set?
    c. Order point
    d. Forecasts
    e. LTdays
4. Tell us what you know about the Proposal/Batch/Shortage categorization
    a. Do you have any input on our proposition regarding ABC-XYZ classification?

Appendix E. Demand Integration Classifications

Reference Classification

Table E.1 Distribution of items from the reference classification.

	A (high)	B (average)	C (low)
X (high)	10.05%	6.20%	4.44%
Y (average)	11.31%	11.73%	13.65%
Z (low)	3.52%	6.95%	32.16%

Classification 1-6

Table E.2. Distribution of items from classification 1.

	A (high)	B (average)	C (low)
X (high)	13.82%	9.10%	8.26%
Y (average)	7.83%	10.87%	15.16%
Z (low)	2.19%	5.48%	27.30%

Table E.3. Distribution of items from classification 2.

	A (high)	B (average)	C (low)
X (high)	14.45%	9.44%	9.61%
Y (average)	7.77%	11.03%	15.79%
Z (low)	1.75%	5.10%	25.06%

Table E.3. Distribution of items from classification 3.

	A (high)	B (average)	C (low)
X (high)	15.29%	10.28%	10.11%
Y (average)	7.69%	11.45%	17.79%
Z (low)	1.25%	3.93%	22.22%

Table E.4. Distribution of items from classification 4.

	A (high)	B (average)	C (low)
X (high)	15.71%	11.03%	10.61%
Y (average)	7.35%	11.11%	19.72%
Z (low)	1.42%	3.59%	19.47%

Table E.5. Distribution of items from classification 5.

	A (high)	B (average)	C (low)
X (high)	16.37%	10.94%	10.94%
Y (average)	7.10%	11.95%	20.55%
Z (low)	1.25%	3.01%	17.88%

Table E.6. Distribution of items from classification 6.

	A (high)	B (average)	C (low)
X (high)	13.78%	8.86%	16.46%
Y (average)	6.02%	6.02%	28.65%
Z (low)	1.00%	1.00%	18.21%

Past Classification

Table E.7. Distribution of items from the past classification.

	A (high)	B (average)	C (low)
X (high)	10.99%	6.34%	5.16%
Y (average)	10.06%	12.09%	14.79%
Z (low)	2.45%	7.19%	30.94%