Exploring the Impact of Business Infrastructure on a Multi-Echelon Inventory Control System

A case study of a distributing company

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Abstract

Inventory management is crucial for organizations, with inventory control being a key component. Efficient inventory control involves balancing various business functions' goals, while also managing economies of scale (EOS) and uncertainties. Multi-echelon inventory control systems (MEICS) consider interdependent stocks and have gained importance with advancements in inventory control techniques. MEICS are particularly significant in industries dealing with perishable goods due to their complexity and high integration needs.

The performance of inventory control systems (ICSs) depend not only on technical aspects but also on organizational context. This thesis explores a large grocery retailer's MEICS, considering both technical aspects and organizational context. Drawing from de Vries (2005), it aims to analyze the Company's MEICS functionality and identify organizational factors affecting its performance.

This master's thesis uses an embedded single-case study, combining interviews and archival records from the Company. It begins by understanding theoretical concepts and the Company's MEICS, then combines quantitative and qualitative data analysis. Finally, the thesis culminates in a cross-analysis, between the exploratory findings and established theory.

The study finds excessive inventory levels but low availability for the products. This discrepancy may be due to inventory levels being presented weekly in the thesis while availability is measured daily by the Company. The analyzed RDC exceeds the Company's inventory turnover rate goal, which may not accurately reflect market conditions since it is set globally.

The study reveals numerous potential underlying reasons for this outcome, including a complex organizational structure, misaligned objectives, inadequate definitions and measurements of KPIs, insufficient information sharing, an ERP system that lacks integration of the multi-echelon aspect of its inventory setup, and differing levels of system knowledge among users. According to established theory, these components of business infrastructure are considered to degrade the efficiency of the Company's MEICS, which is potentially the cause of the observed excessive inventory levels and suboptimal performance in terms of availability and inventory turnover rate.

Keywords: Supply Chain Management, Inventory Control, Multi-Echelon, Business Infrastructure

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Abbreviations

SC	Supply Chain
SCM	Supply Chain Management
ICS	Inventory Control System
MEICS	Multi-Echelon Inventory Control System
DC	Distribution Centre
CDC	Central Distribution Centre
RDC	Regional Distribution Centre
EOS	Economies of Scale
FTL	Full Truck Load
RQ	Research Question
HT	High Turnover
LT	Low Turnover
FD	Fluctuating Demand
DO	Distribution Orders
PMS	Performance Measurement and Management System
OTD	On-Time Delivery
FY	Fiscal Year
SPOD	Service Provider Operations Development
BSC	Balanced Scorecard
COV	Coefficient of Variation
PO	Purchasing Order

CO	Customer Order
AIL	Average Inventory Level
CRT	Carton

Chapter 1

Background

This first chapter commences by providing a comprehensive overview of the master thesis, offering insight into its context and purpose. Sections 1.1 to 1.2 delve into the case company and the existing distribution network. Following this, Sections 1.3 to 1.6 the formulation of the problem, set clear objectives, pose chosen research questions, and establish the scope of the study. Finally, the chapter concludes by highlighting the contribution of this master thesis to knowledge development within theory practice in Section 1.7.

Supply chain management (SCM) plays a vital role in almost all organizations and is acknowledged by top management as a strategically important area. The overall investment in inventories is substantial and therefore poses significant opportunities for improvement. There are several methods today on how to manage inventory control which can provide a competitive advantage. The main purpose of inventory control is to balance the goals of the different business functions such as marketing, purchasing, and production. In some scenarios, the requirement for certain stocks arises due to economies of scale (EOS) and uncertainties. EOS generate the need for ordering in batches which increases the cycle inventory, while uncertainties in supply and demand combined with lead times in production and transportation, lead to the necessity for safety stocks. However, organizations can often reduce inventories without incurring additional costs by adopting more efficient inventory control tools. (Axsäter 2015)

Multi-echelon inventory control is a concept that takes the interdependence between different stocks into consideration. (Axsäter 2015) This can be managed through different multi-echelon inventory control systems (MEICS). Research and publications about MEICS started at the end of the 1950s and the interest in the field has increased ever since. This is largely because of the complexity and practical relevance of it but also because of the growing interest in SCM. (de Kok et al. 2018) Effectively managing MEICS is a critical component of supply chain (SC) operations and is most commonly used in production and distribution. Due to new information technologies and new general and efficient inventory control techniques that have evolved during the last two decades, the opportunities for effectively managing MEICS have significantly increased. (Axsäter 2015)

SCs operating in the market of perishable goods are extra sensitive to good inventory control. Perishable goods are defined as "products that have a finite shelf life and/or face physical decay" (Transchel & Hansen 2019). To manage inventory of perishable products can be rather demanding in terms of uncertain demand, limited shelf life and high customer requirements regarding service level. (Minner & Transchel 2010) The key parameters to consider in this type of SC are demand, price, price discount, rate of deterioration, shelf life, shortage, stock out, and replenishment policy (Chaudhary et al. 2018). A high integration in the SC is also essential to manage it efficiently with minimal waste (Småros 2018). Due to a competitive market and the high integration of today's SC, the multi-echelon inventory with centralized decision and information sharing takes on great importance in the perishable goods industry (Chaudhary et al. 2018).

The effectiveness of inventory control systems (ICS) is closely tied to their organizational context, as organizations frequently employ organizational measures to mitigate shortcomings in inventory planning and control. Therefore, it is essential to consider not only the technical aspects of an ICS but also the business infrastructure when seeking to understand its performance. (de Vries 2005)The subject of inventory control has been well researched, yet the intersection between inventory control and business infrastructure has received comparatively less attention. Therefore, this master thesis deals with how a large grocery retailer, from now on called the Company, currently manages their two-level divergent MEICS for perishable goods. The focus is to find whether the Company takes advantage of all the benefits that such a system may bring, and if the organization setup is fit for purpose.

1.1 Description of the Case Company

The Company is one of the world's largest food exporters and restaurant businesses. It is part of a larger conglomerate and sell products that are available for consumers in stores. The stores are franchised by the larger conglomerate, hence the Company's customers are the stores, who are referred to as retailers from now on. The products sold by the retailers are divided into two categories - *Food Service* which is food cooked and served portion wise by the employees, and *Consumer Packaged Goods* which is food bought in packages that the customer opens themselves.

Before 2017 the Company used a 4PL to handle its SC, but after realizing the need for enhanced oversight and control over the SC, the Company took proactive measures to assume direct responsibility for the SC's strategic planning. Today, the Company plays a central role in shaping and managing the entire food SC, from sourcing eatables to distribution. The reliance on external parts has been delimited to manufacturing as well as certain areas of the distribution such as transportation and running the distribution centres (DCs) where 3PL is used. The Company is hence responsible for designing dishes and planning the distribution.

1.2 Current Distribution Network

The distribution network at the Company consists of a central distribution centre (CDC) in Helsingborg, Sweden, and multiple regional distribution centres (RDCs). There are in total 23 RDCs in the world where 12 are situated in Europe. The countries the Company is present in are offered two different distribution set-ups depending on how large the Company's market is in the specific country. Countries with larger markets are given the *Full Service Offer* which includes that the Company helps the retailers distribute all the way to the stores. The group with the smaller markets is given a *Base Country Offer* which only includes that the Company distributes to the country border and then the retailers need to solve the distribution from there. The distribution is divided into an inbound flow that refers to the distribution from the production to the DCs or between the CDC and the RDCs, and an outbound flow that refers to the distribution from the DCs to the retailers.

There are many possible distribution flows when distributing products to retailers. The CDC in Helsingborg is a large distribution hub and works in three different ways. First and foremost it serves as an RDC for the Scandinavian countries, secondly, it serves as a CDC for the rest of the RDCs, and lastly as a DC for export flows to the base countries. The CDC is supplied directly by the Company's suppliers which are for the most part situated in Scandinavian countries, but also in other parts of Europe. The RDCs can be supplied directly from the suppliers, but are mostly supplied by the CDC. The RDCs in turn only supply Full Offer retailers in their region. Base Country Offer retailers, on the other hand, are supplied to the country border either directly from the supplier or the CDC. See Figure 1.1 for an illustration of the distribution flows.

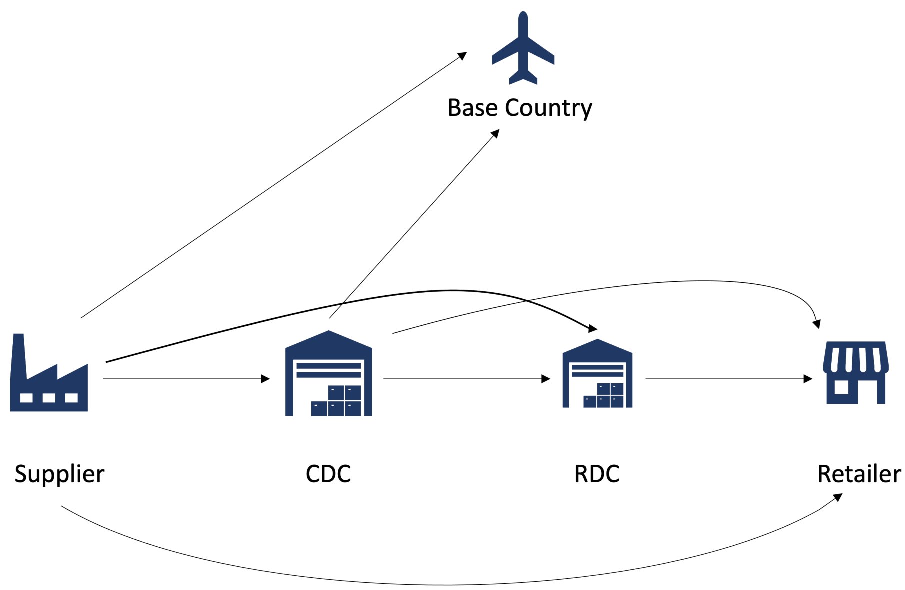


Figure 1.1: Distribution flow at the Company.

What distribution flow used is mainly based on the amount of product needed since the Company always drives Full Truck Load (FTL). Generally, the Company has rather small drop sizes when distributing its products to the retailers. The average drop size is 9 m^3 for a retailer which is equal to about four EUR pallets. Other factors that can affect the choice of distribution flow are the type of product being shipped and the shelf life of the product.

Since the Company's products are perishable there are many requirements to consider. One important requirement is the temperature. There are effectively four different temperature zones: frozen ($-18°$C - $-25°$C), chilled ($0°$C - $6°$C), ambient ($12°$C - $25°$C) and dry (no temperature restrictions). However, during the distribution the Company uses different numbers of temperature zones to facilitate the process. The goods are supplied in the four temperature zones, stored in three temperature zones (dry is stored as ambient) and shipped in two temperature zones (dry and ambient are shipped as chilled). Apart from the different temperature zones, products are required to have different labels in different countries. This makes a Swedish and Spanish labeled product different products even though it is the same product in the package. Therefore, when a product is labeled it is not possible to ship it to a country the label is not fit for. Shelf life is also a restriction that affects the distribution. Different products have different shelf life which is important to take into consideration when planning for supply.

1.3 Problem Formulation

The Company is dissatisfied with the performance of its current SC regarding availability and inventory turnover rates. As a result, the Company intends to evaluate whether the operation of its MEICS plays a role in contributing to this suboptimal performance. With a commitment to continuous improvement, the Company aims to look further into its concerns by thoroughly investigating the suspected issues and scrutinizing its existing system. To understand why the MEICS performs in a certain way, it will also be necessary to look into soft factors such as organizational structure, information sharing and synchronization, performance measurement, and IT system.

1.4 Objective

The thesis objective is to investigate parts of the Company's product flow in relation to its MEICS. The results are supposed to give insights into whether the MEICS operates as expected. The results also aim to give an idea of what organizational factors could play a part in the performance of the MEICS.

1.5 Research Questions

1 How does the MEICS perform in terms of managing inventory levels, product availability, and inventory turnover rate for product A-N?

2 What role does the Company's organizational structure, performance measurement system, information sharing and synchronization, as well as IT systems play in the outcome of the first question?

1.6 Thesis Scope

Due to limited time for the project, the research is delimited by a number of factors. Firstly, the research is only focusing on the distribution flow between the CDC and the RDC situated in Parma, see Figure 1.2, hence only taking parts of the inbound flow for a Full Offer country into consideration. The results from this flow is expected to give insights in the performance of the MEICS that can be extrapolated to distribution flows between the CDC and other RDCs. The reasoning behind choosing Parma is that it is one of the Company's largest RDCs, thus there is a lot of data to be analyzed.

Secondly, the time frame for the data analysis is limited to FY23, which starts in September 2022 and ends in September 2023. The reason for choosing this time span is because data during Covid-19 does not portray accurate demand and thus should not be considered. Data before Covid-19 is too old to reflect today's demand and inventory levels.

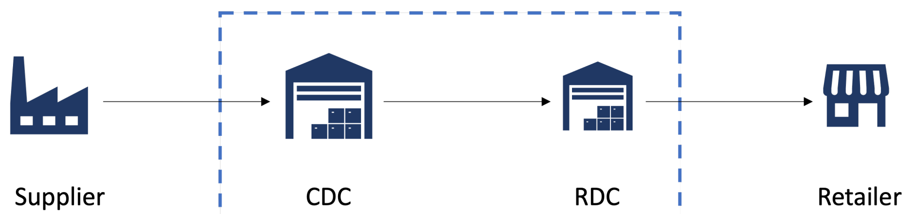


Figure 1.2: Chosen distribution flow to investigate.

Lastly, the research is limited to 14 carefully selected products, see Table 1.1. The products belong to three different service level groups where six products have service level 99% (SL1), five products have the service level 98% (SL2), and three products the service level 90% (SL3). From the beginning of the thesis there were six SL2 products and two SL3 products. The reason for only having two SL3 products was that there were no more products at the service level that fit into the chosen distribution flow. However, during the thesis it was discovered that product L had been changed from SL3 to SL2 after FY23 and therefore the product was changed in the thesis to an SL3 product. Since this was discovered when most of the data analysis was done, there was not enough time to pick out and analyze a sixth SL2 product and thus only five SL2 products are investigated.

In each service level, two high turnover (HT) products, two low turnover (LT) products and two products with fluctuating demand (FD) are chosen. This segmentation of products is referred to as *Product Type* in the thesis. The HT and LT products are decided based on the quantity sold during FY23 and the FD products are chosen based on the standard deviation on the demand as well as plots of the products demand during FY23. In service level 90%, only two LT products are available, but as product L is changed from SL2 to SL3, there is now one HT SL3 product available as well. Because of this there is only one HT SL2 product. The reason for investigating different Product Types are to see if there are any substantial differences regarding operational difficulties.

Table 1.1: Chosen products and their service level, and product type.

Product	Service Level	Product Type
A	99%	HT
B	99%	HT
C	99%	LT
D	99%	LT
E	99%	FD
F	99%	FD
G	98%	HT
H	98%	LT
I	98%	LT
J	98%	FD
K	98%	FD
L	90%	HT
M	90%	LT
N	90%	LT

1.7 Contribution to Knowledge Development Within Theory Practice

This master thesis contributes with knowledge about how MEICS employed in food industries can be affected by organizational factors. The thesis also provides a practical example on how to apply de Vries (2005)'s framework when investigating a ICS.

Chapter 2

Methodology

The methodology employed in the study is carefully outlined in this chapter. It starts with an exposition of the research structure in Section 2.1, followed by a comprehensive clarification of the chosen research approach, strategy, design, and method in Sections 2.2 through 2.5. Section 2.6 delves deeper into the data analysis steps, while Section 2.7 provides an overview of the thesis workflow. The chapter ends with a discussion on how the master thesis ensures research quality in Section 2.8.

Methodology refers to the approach taken in order to execute a thesis. Rather than delving into details about each step, the methodology provides a comprehensive outline for effectively pursuing the thesis objective and gaining enhanced knowledge of the subject matter. (Höst et al. 2006)

2.1 Structure of Research

When conducting research it is crucial to carefully structure the study, ensuring clarity and coherence not only for the researchers to follow but also for those accessing the study later on. Saunders et al. (2012) present the research onion, see Figure 2.1, as a model that could be used to structure a research. The model starts with deciding on the research approach and follows with deciding the research strategy, research design, and lastly the research methods. In the following sections each of these concepts are described in detail.

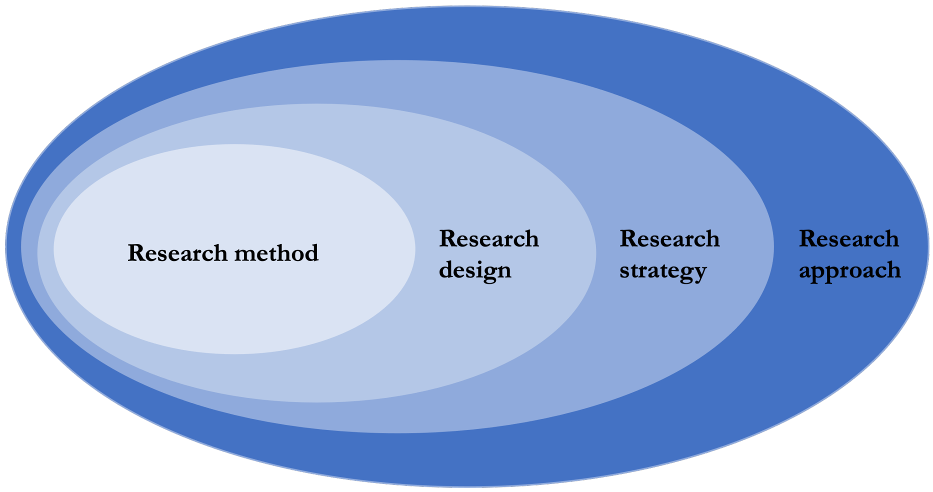


Figure 2.1: The Research Onion inspired by Saunders et al. (2012).

2.2 Research Approach

Two commonly used research approaches are inductive and deductive reasoning. If the initiation of a research process involves collecting data in order to explore a certain phenomenon and then formulate a theory based on the findings, then inductive reasoning is applied. However, if the initiating process is characterized by a literature review to comprehend an established theory and then attempting to test that theory, deductive reasoning is employed. (Saunders et al. 2012)

In practice, strictly adhering to one approach can often prove challenging, leading researchers to navigate between the two approaches. A combination of inductive and deductive reasoning is referred to as abductive reasoning. Abductive reasoning is a more flexible approach in terms of developing and analyzing theories since it allows for simultaneous engagement in both literature review and data collection. (Saunders et al. 2012) Based on this it is decided to apply an abductive research approach to this master thesis since both empirical data and theory from the literature are required to answer the research questions (RQs).

2.3 Research Strategy

Which research strategy to choose should, according to Höst et al. (2006), be based on the main purpose and objective of the thesis. A thesis's main purpose could be descriptive, exploratory, explanatory, or problem-solving.

Descriptive studies seek to identify and provide detailed descriptions of how a phenomenon operates.

Exploratory studies seek to develop a deeper understanding of a phenomenon.

Explanatory studies seek to uncover the causations behind how a task or process is performed.

Problem-solving studies seek to identify a solution for a recognized problem.

Furthermore, Höst et al. (2006), describe four commonly used research strategies when writing a thesis: survey, case study, experiment, and action research.

Survey is a strategy with the purpose of explaining and summarizing a broad issue and therefore the purpose is mainly descriptive. The survey method involves asking questions to a population or a representative sample of people in order to enable conclusions drawn regarding the entire population.

Case study is a commonly used strategy in studies where the purpose is exploratory and seeks to describe a phenomenon or an object. Case studies are valuable tools when examining contemporary phenomena, particularly when it is closely connected to its surroundings. It is a commonly applied method within organizations to understand how effective work practices are. The findings from a case study are specific to the particular case and purpose. Therefore it is important to not generalize the conclusions drawn and claim their applicability for other cases. A case study is a flexible strategy which means that the methodology is allowed to change during the research if the prerequisites are to shift. The data used in a case study is usually qualitative and can be collected by open interviews, observations, and analysis of archival records.

Experiment is a fitting strategy when a more controlled approach is required in order to identify and describe causation behind a phenomenon, in other words when the study has an explanatory purpose. An experiment begins with a definition of goals to later form a hypothesis. The next step is to define which independent variables that could affect the particular phenomenon. The result is measured on dependent variables. The design of an experiment is fixed, so no changes can be made once it has begun.

Action research strategy is suitable when aiming for improvement while simultaneously studying the subject. Problem-solving studies can benefit from this strategy. The process of the strategy is iterative and can be divided into three steps: observing, solution proposal, and evaluation.

In contrast to Höst et al. (2006), Yin (2014) describes a different perspective on the application of the different research strategies. This perspective is based on the fact that the purpose of the study is irrelevant when deciding which research strategy to use. Instead, Yin (2014) describes three conditions to consider before deciding which research strategy to conduct: (i) The type of RQ, (ii) The degree of control a researcher possesses over real behavioral events, and (iii) The extent to which focus is placed on contemporary events rather than exclusively historical events. See Figure 2.1.

The RQs for this thesis are of the type how and why. This is because the objective of the

	Form of RQ	Requires control over behavioral events	Focuses on contemporary events
Experiment	How, Why?	Yes	Yes
Survey	Who, What, Where, How Many, How Much?	No	Yes
Archival Analysis	Who, What, Where, How Many, How Much?	No	Yes/No
History	How, Why?	No	No
Case Study	How, Why?	No	Yes

Table 2.1: Conditions to consider when deciding research strategy. Adapted from Yin (2014).

thesis is to understand how the Company's MEICS is built and operationalized followed by how and why business infrastructure impacts its performance. Regarding control of behavioral events, there is no such requirement and additionally, the thesis focuses on contemporary events. Based on this, the appropriate research method to apply according to Yin (2014) is a case study. Case study as the chosen research method is also supported by Höst et al. (2006). This thesis is seen to be a combination of an explanatory and exploratory study as it aims to delve deep into the presented area with the objective of finding how business infrastructure affect the performance of the MEICS. In Chapter 7, recommendations for the Company's next steps are presented. While these might give the impression of problem-solving, it is important to note that this is not the main purpose of the thesis.

2.4 Research Design

According to Yin (2014), there are four basic types of case studies, see Figure 2.2. *Type 1* is a holistic, single-case study design, *Type 2* is an embedded, single-case study design, *Type 3* is a holistic, multi-case design, and lastly *Type 4* is an embedded, multi-case design. The difference between single and multiple case study designs is that for a single-case study design, only one case is studied with the objective of drawing conclusions from that specific case. For a multiple case study design, on the other hand, two or more cases are studied with the objective of getting more robust results that can improve the generality of the conclusions. When considering if the study design is holistic or embedded it is a matter of whether the case study focuses on one or more units of analysis. If it only focuses on one unit of analysis the research design is holistic, if it focuses on more units of analysis it is an embedded design. All the different types of cases require, apart from the case study itself, a study of contextual factors in relation to the case. This is illustrated in Figure 2.2 by the blue box outlining the gray box.

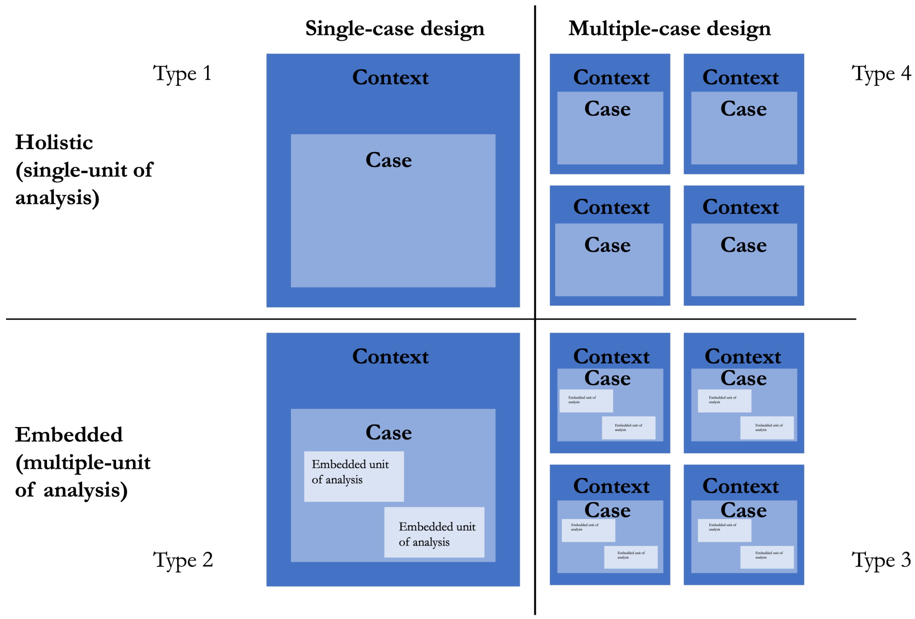


Figure 2.2: Case study design by Yin (2014).

This master thesis uses an embedded single-case study as it focuses solely on the Company's situation but consider analysis both on the performance of its MEICS as well as how business infrastructure impacts the performance. Hence there are two subnodes in the case study. There are five rationales for when to use a single-case study. The rationals are (i) A *critical case*, meaning that the case can represent the critical test of a significant theory, (ii) An *extreme or unusual case* where a specific case is interesting in itself to study, (iii) A *common case* where circumstances and conditions are captured with the objective to describe an everyday situation, (iv) A *revelatory case* when there is an opportunity to study a before never studied case, (v) A *longitudinal case* with the objective to study the same case at two or more different points in time and compare the observations. In this case study, rational (iii) can be used to justify the choice of a single-case study.

2.5 Research Method

When conducting a case study there are three common techniques for gathering data: interviews, observations, and analysis of archival records. Höst et al. (2006) Apart from gathering data the study should also be based on theory that is conducted by a literature review. Höst et al. (2006)

2.5.1 Interviews

Interviews conducted in a study can be structured, semi-structured, or opened. Which type of interview that is done depends on the purpose of it. A structured interview is close to an oral survey where the questions are decided in advance and the order of the questions are also decided. This can be good when comparing the answers between several interviewees. Semi-structured interviews are less rigid and use prepared questions as support but the conversation is more open and the questions can appear in different orders. An open interview only uses questions to make sure that the interviewee is keeping to the subject and is otherwise an open conversation, hence the order of the questions is not set. In an open structured interview, the main objective is to capture the interviewee's experiences of the qualities of a phenomenon. Höst et al. (2006)

In this master thesis, the interviews conducted are held in two separate rounds. The first round of interviews is with the objective of understanding the current MEICS and how it is operated. The first round is therefore explorative and thus an open structure is used. The interview is based on questions from an interview guide, see Appendix A.1 which is divided into different areas that should be touched upon during the interview. The second round of interviews is with the objective of getting insights into how the business infrastructure can possibly affect the performance of the Company's MEICS. The second round of interviews is also explorative but needs to incorporate some recurrent questions since the interviewees' answers are compared to each other. Therefore a semi-structured interview guide is used, see Appendix A.2 and A.3. To get a thorough overview of the MEICS the first round of interviews are conducted with various people from the Company with different areas of responsibilities regarding the Company's inventory control. In contrast, the second round predominantly focuses on engaging Delivery Planners (Delivery Planners), who play a pivotal role in determining the distribution flow pertinent to the scope of this master thesis. All interviews are documented and recorded.

2.5.2 Observations

According to Höst et al. (2006), there are two types of observations: participant observation and direct observation. If the observer has a role in the proceedings to be observed it is referred to as a participant observation. A direct observation, on the other hand, occurs when the observer just takes notes and describes what is happening without actively participating in what is being observed. Data from the observations can be gathered through journaling. This master thesis is not making use of any observations.

2.5.3 Archival Records

Archival records are documentation that has been prepared for a different purpose than for the study. Analysis of archival records can both result in qualitative and quantitative data. Since the data has been produced for different proposals it is important to be careful while analyzing it and always be mindful of possible biased data, see Section 2.6. Höst et al. (2006)

Archival records used in this master thesis are documentation and data provided by the Company. The documentation are PowerPoints and written material about the Company's ICS and SC as well as data from the Company's database.

2.5.4 Literature Review

According to Höst et al. (2006), there are three steps to be followed when doing a literature review: (i) *Search broadly*, (ii) *Select*, and (iii) *Search deeply*. Step (i) refers to the beginning of the literature study where it is good to use many search words and broaden the search to find multiple studies, books, and articles that could be of interest to the thesis. In step (ii) the sources found in step (i) should be screened with the purpose of selecting sources that will bring value to the thesis. Lastly in step (iii) the search should be narrowed down to specific topics that have been found interesting for the thesis to dive deeper into.

Within the thesis, this is applied as follows:

(i) *Search broadly*
Reference material is obtained from multiple sources such as reference lists from previously written master theses in the same field of study, the university database Lubsearch, recommended articles from the supervisor, and reference lists from several applicable research articles. When searching in the Lubsearch database, the following keywords are used: inventory control, inventory management, multi-echelon, perishable inventory, information sharing, organizational structure, supply chain maturity, technological maturity, IT systems, ERP and performance measurement system.

(ii) *Select*
After the broad search for reference material, a careful selection of the most relevant and credible ones is conducted. The relevance is determined by the similarity with the case company and the RQs as well as the contribution to the understanding of the specific field of study. The credibility of the material is based on the five criteria described in Höst et al. (2006): (i) Has the material been reviewed, and if so, how and by whom, (ii) Who stands as a guarantor of credibility, (iii) Is the survey method credible, (iv) Are the results produced in a context that is relevant for this thesis, and (v) Have the results been confirmed or led to recognition and been referenced in other credible contexts.

(iii) *Search deeply*
Once the selection is made, more focused research is conducted. The reference lists from the selected articles are followed up and also identified authors particularly active within the RQs are searched for in the Lubsearch database to find more relevant material.

2.6 Data Analysis

According to Yin (2014) five different analytical techniques can be applied when doing a case study: pattern matching, explanation building, time series, logic models, and cross-case synthesis:

Pattern matching is when a pattern derived from empirical evidence is compared with an anticipated or predicted pattern. Through the comparison, conclusions can be drawn based on whether the patterns match or not. If the patterns match the results can enhance the internal validity of a case study.

Explanation building is a more advanced form of pattern matching and is suitable for explanatory case studies. The objective is to analyze the case study data by formulating or constructing an explanation for the case.

Time series is a technique where only one variable, either dependent or independent, is being scrutinized. When a significant amount of time data points constitute this one variable, statistical tests can be employed for an analysis of the data. However, it can be challenging to define the start and ending points of this one variable, which makes it a more complicated sequence. Regardless of this complication, it is a valuable strength of case studies, the capacity to track changes over time.

Logic models are valuable techniques when doing case study evaluations and examining theories of change. The logic model outlines and simplifies a complex series of events or occurrences happening over an extended period. These events follow a repetitive cause-effect pattern, where a dependent variable in an earlier stage becomes the independent variable for the next stage

Cross-case synthesis is a technique where findings across multiple cases, a minimum of two, are compared and combined. Analyzing multiple cases is likely to facilitate an easier examination, and the findings are expected to be more robust and enhanced compared to a single-case scenario.

The chosen analytical technique for this master thesis is pattern matching since both qualitative and quantitative data are being analyzed and compared with theoretical practices to find patterns. This is used to understand the connection between the performance of the Company's MEICS and its business infrastructure. Additionally, the majority of quantitative data is being analyzed using the time series technique for enhanced insight and interpretation.

2.6.1 Qualitative Analysis

Qualitative analysis refers to extensive reviews of data such as text documents, transcribed interviews, or archival documents. Considerable attention is placed on the presence and frequency of certain words, concepts, and descriptions. There are different ways of approaching qualitative analysis, whereas this thesis applies the approach of the editing method. The editing method approach is based on the search for keywords in the obtained data material, which later is put into different subject categories. Höst et al. (2006)

According to Höst et al. (2006), qualitative analysis can be divided into four steps: data collection, coding, clustering, and conclusions. In this thesis, the collected qualitative data is constituted of the conducted interviews with various employees at the Company. Coding refers to important statements and passages being connected to one or multiple keywords which are then clustered in the following step. Clustering aims to analyze diverse perspectives related to a specific keyword expressed by various people. In the final step, conclusions is drawn based on the clustered data. The drawn conclusions must always be traceable back to the original collected material.

For the first round of interviews, the collected data is divided into different categories regarding the MEICS, see Appendix A.1. In the second round, the choice of the data collected depends on the obtained quantitative data described in Section 2.6.2 below, see Appendix A.2 and A.3.

2.6.2 Quantitative Analysis

Quantitative analysis involves examining quantitative data, which can be expressed in terms of numbers and numerical values. Various statistical methods are commonly used to perform these analyses. Quantitative techniques can both help with exploring data to enhance understanding but also to illustrate relationships and previously formulated hypotheses. Höst et al. (2006) Within this thesis quantitative analysis is mainly used for the latter purpose.

The goal of the quantitative analysis for this thesis is to examine how well the MEICS performs regarding inventory levels, product availability and inventory turnover rate and to discover possible explanations for the performance. The data used is provided by the Company's databases and covers historical data of each day for the fiscal year (FY) of 2023. The data gathered for each product A-N is the following:

- Actual inventory levels at the CDC and the RDC in Parma
- Actual sold quantity at the RDC in Parma
- Forecasted sales quantity at the RDC in Parma
- DO quantities sent from the CDC to the RDC in Parma
- Product availability at the RDC in Parma
- Transport lead time between the CDC and the RDC in Parma
- Current safety stock levels at the RDC in Parma
- Actual inflow to the CDC in Helsingborg
- Actual outflow from the CDC in Helsingborg
- Shelf life

2.7 Thesis Work Outline

The research is divided into three different parts, see Figure 2.3: (i) *Empirical framework* with the goal of mapping the inventory control process at the Company, (ii) *Exploratory analysis*, and (iii) *Cross analysis* with the objective to draw conclusions from the analysis within part (ii).

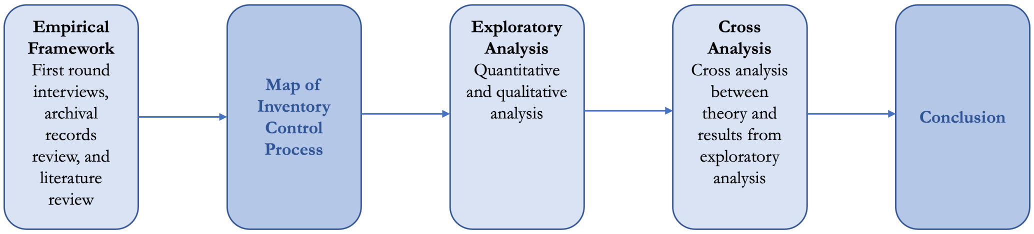


Figure 2.3: Illustration of the thesis work outline.

2.7.1 Empirical Framework

In the first phase of the research, the objective is to get an understanding of important theory as well as of the Company's MEICS. The deliverable is a written description of the inventory control processes at the Company. Actions taken in this phase are open structured interviews and reviewing archival records handed from the Company. The literature review is conducted as described in Section 2.5.4

2.7.2 Exploratory Analysis

The second phase incorporates both quantitative and qualitative data analysis. The quantitative data is provided by the Company through the Company's databases and incorporates defining and scrutinizing inventory turnover rate and product availability as well as analyzing the inventory levels at the CDC in Helsingborg and the RDC in Parma. The qualitative data involves the second round of interviews and contributes with information regarding how business infrastructure affects the performance of the Company's MEICS.

2.7.3 Cross Analysis

The final part of the thesis involves a cross analysis between the findings in the exploratory analysis and theory. The analysis has the objective to find connections between the performance of the Company's MEICS and its business infrastructure. The deliverable is conclusions regarding these connections.

2.8 Research Quality

To be able to verify the quality of the research different techniques can be used. The ones used in this master thesis are described below.

2.8.1 Triangulation

When doing a case study it is suggested to use more than one source of data. The reason for this is that using multiple sources strengthens the findings and lead to higher-quality research due to the converging lines of inquiry. Using multiple sources in research to strengthen the quality is called triangulating. It is notable that triangulation has not been done if the research consists of multiple sources that show different findings or that are used for different purposes. If triangulation is practiced the sources should strengthen the same findings. Yin (2014)

Triangulation is exercised in this master thesis by: (i) using archival documentation: (ii) performing a data analysis on data from the Company's databases, and (iii) doing deep interviews with multiple employees at the Company, all to get an understanding of why the Company's MEICS is performing at the current level. This helps secure the quality of the results and make sure the conclusions are valid.

2.8.2 Construct Validity

When collecting data for a study it is crucial to ensure high quality in both the data and its collection methods. It is essential to clearly define the concepts that are researched and establish operational measurements to gauge these concepts accurately. Failure to do so may result in biased data, as the researcher might steer data collection to align with his or her preconceived theory. Construct validity, as emphasized by Yin (2014) addresses this concern, offering three different tactics to uphold data quality. The first tactic is to use multiple sources when collecting the data to create converging lines of inquiry as described in Section 2.8.1. The second tactic is to create a chain of evidence that can all support the conclusion. Lastly, it is important to let key informants review the study before it is published. Construct validity is ensured in this master thesis by utilizing multiple sources and seeking iNeed Plannerut from supervisor Fredrik Olsson, as well as third-party reviewers before finalizing publication.

Data Quality

It is important to consider the quality of the data collected for the quantitative analysis. According to Pipino et al. (2002) data quality is a multi-dimensional concept that considers both objective and subjective evaluation aspects. Three functional forms are suggested to help measure data quality. These are simple ratio, min or max operators, and weighted average. The simple ratio calculates the proportion of preferred results compared to the overall outcomes and incorporates the data correctness, completeness, and consistency. Min or max operators is used to handle the aggregation of multiple data quality indicators, with the minimum value reflecting a conservative assessment and the maximum value offering a liberal interpretation. It is applicable to various dimensions like believability, appropriate amount of data, timeliness, and accessibility. In scenarios involving multiple variables, an alternative to using the minimum operator is to calculate a weighted average of the variables. Weighted average should mostly be used if the importance of each value is well known.

This thesis uses simple ratio and weighted average to ensure data quality. For the simple ratio, the correctness is measured by considering how many data points that are collected during normal situations, in other words, when there has not been a disruption or special event affecting the performance of the MEICS. The completeness is measured by considering how many of all the rows that are not blank, hence whether there is data collected or not. The consistency is measured by considering if the data is collected in the same way for all the products over the chosen time horizon. All of these metrics are considered to be equally important to ensure high data quality and therefore the weights given to each metric is $\frac{1}{3}$.

2.8.3 Internal Validity

The internal validity focuses on the validity of the findings in a study and ensures that the findings correspond to reality. This mostly concerns explanatory and causal studies. The tactics suggested by Yin (2014) are pattern matching, explanation building, addressing rival explanations, and using logic models. As this master thesis is an exploratory study internal validity is not of the highest concern, but since pattern matching is applied, as described in Section 2.6, internal validity is still ensured.

2.8.4 External Validity

The external validity concerns whether the results and findings from a study are applicable to a general case. (Yin 2014) proposes to use theory in the single-case study and replication logic in the multiple-case study to belay the generalization in the study. This master thesis have an extensive literature study to compare with and make sure external validity is achieved.

2.8.5 Reliability

Reliability concerns whether another researcher arrives at the same findings and conclusions if they conduct the same study with the same procedures again. This means inter alia that procedures followed need to be documented so that it is possible to replicate the study. (Yin 2014) suggests two tactics to transcend this. The first one is the usage of a case study protocol to help with documentation. The second one is the development of a case study database. In other words, a researcher should conduct the study with the mindset that he or she is always explaining and documenting for a third party. To ensure reliability in this thesis all the research is documented in a journal and all the material is gathered in a Google Docs.

Chapter 3

Theory

This chapter initiates with a summary of important theory regarding the significance of inventory and inventory control, spanning from Section 3.1 to Section 3.2. More focused theory on multi-echelon inventory control is described in Section 3.3. Sections 3.4 through 3.7 delve into diverse facets of business infrastructure that can significantly impact inventory control performance, encompassing performance evaluation, collaboration, maturity, and information technologies.

de Vries (2005) has created a framework for how to study inventory control together with its organizational setting. He suggests three different subsystems: inventory planning and control, physical context, and organizational setting. The first subsystem incorporates the level of planning, degree of formalization, and demand characteristics, whereas the second subsystem considers the characteristics of the production or distribution system such as types of inventories and products, the stock-keeping process etc. The third subsystem, organizational setting, can be divided into the two subcategories superstructure and structure of positions. Superstructure refers to the functions and activities related to inventory systems and studies factors such as the complexity of planning and control, organizational structure, the (perceived) importance of control, and size of the organization. The structure of position refers to the formal and actual relationship between groups and persons in the organization, the knowledge and skills possessed of the subject, formalization of behavior, and specialization. The characteristics of each separate system, and particularly the interaction between them is of importance in explaining and understanding the behavior and performance of the system. See Figure 3.1 for an illustration of this framework.

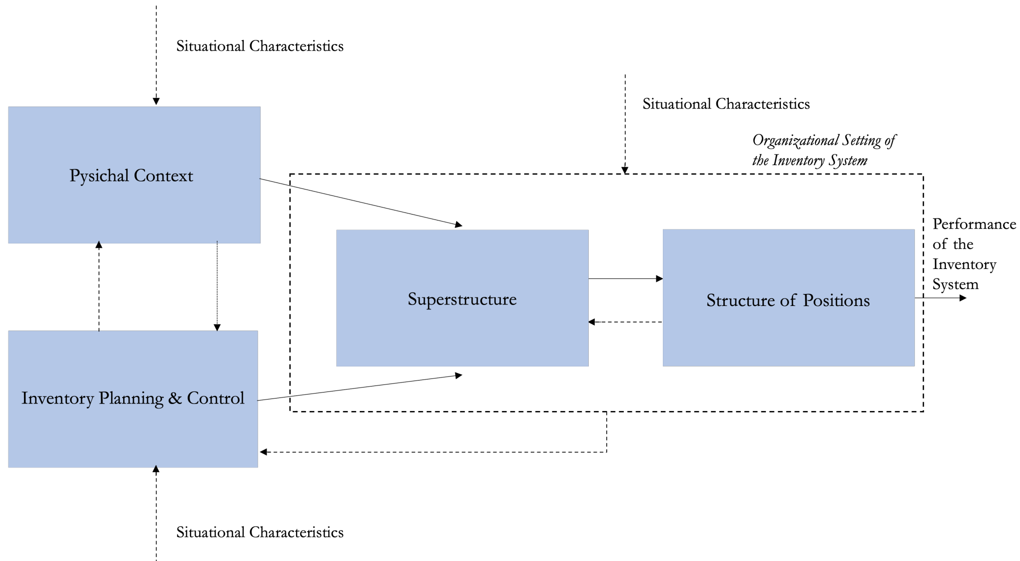


Figure 3.1: Framework for how to study inventory control in relation to its organizational setting. (de Vries 2005)

This thesis is inspired by de Vries (2005)'s framework and this chapter thus incorporates sections about ICSs, but also about business infrastructure and organizational issues such as collaboration, SC and technological maturity and the integration of IT systems.

3.1 The Role of Inventory

One of the main reasons for holding inventory is due to misalignments between supply and demand. Inventory affects asset management, costs, and responsiveness in the SC. More inventory improves responsiveness but increases vulnerability to mark-downs, lowering profits. It also cuts production and transportation costs but raises holding costs. Less inventory, however, boosts turnover but may result in lost sales. Inventory should be reduced without increasing costs or sacrificing responsiveness, the ability to fulfill orders quickly and respond effectively to changes in demand. (Chopra & Meindl 2016)

To establish an efficient and responsive SC, several critical decisions must be made concerning inventory management. These decisions encompass for example cycle inventory, safety stock, and the desired service level. An illustration of cycle inventory and safety stock can be seen in Figure 3.2. (Chopra & Meindl 2016) Understanding the interaction between cycle inventory and safety stock is crucial. For instance, when cycle inventory rises, it allows for a reduction in safety stock while preserving the same service level. In other words, increasing either stock will result in increased service level. (Axsäter 2015) However, this optimization is not without its costs, as is further highlighted in the two subsequent sections.

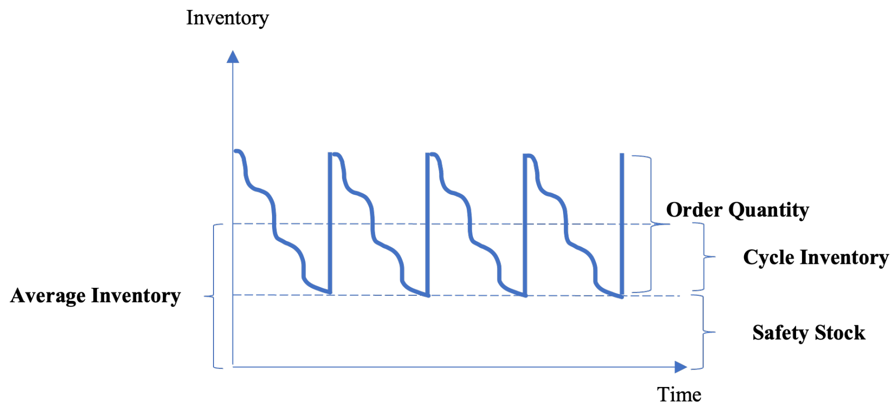


Figure 3.2: Illustration of cycle inventory and safety stock inspired by Chopra & Meindl (2016).

3.1.1 The Role of Cycle Inventory

In order to fulfill current demand it is crucial to have cycle inventory, which is stock that is collected in advance because inventory supply comes in cycles (Muckstadt & Sapra 2010). In other words, cycle inventory represents the average inventory caused by buying or producing items in larger lot sizes than what customers demand. The quantity purchased or produced at a given time is referred to as a lot or batch size. The main purpose of holding cycle inventory is to leverage EOS and lower costs, see Section 3.2.5. (Chopra & Meindl 2016)

While reducing the lot size decreases inventory holding costs, EOS in purchasing and ordering encourages larger lot sizes. It is therefore of great importance to balance these two factors to minimize costs when making decisions about lot sizes. Ideally, cycle inventory decisions should aim to minimize total costs across the entire SC. However, in practice, it is more common for each stage to make these decisions on their own, leading to higher cycle inventory levels and increased total costs within the SC.(Chopra & Meindl 2016)

To minimize cycle inventory, it is essential to decrease lot sizes, aiming to lower fixed costs per lot. This can be achieved by directly reducing fixed costs or by consolidating lots across products, customers, or suppliers. (Chopra & Meindl 2016) Another way to reduce cycle inventory is to reduce the length of the cycles, in other words the lead times which is explained in Section 3.2.3 (Muckstadt & Sapra 2010).

3.1.2 The Role of Safety Stock

Inventory held to fulfill demand exceeding the forecasted amount is referred to as safety stock. This type of stock is mainly necessary due to uncertainty in demand. When determining how much safety stock to carry, one must consider the balance between product availability and inventory holding costs. (Chopra & Meindl 2016) Too little safety stock leads to a reduction in total stock level but at the expense of achieved service level (Yigit & Esnak 2023). Increasing safety stock levels can enhance product availability and profit margins, yet it may not be as beneficial when considering the associated holding costs. Further, having too much inventory can become problematic if demand drops for example due to new market entries. Today's customers put significant pressure on firms to improve product availability, as they can easily check different stores for alternatives. Together with a demand for wider product variety, this necessitates firms to maintain higher levels of safety stock. In summary, a key aspect of SC success lies in finding ways to reduce safety stock without compromising product availability. (Chopra & Meindl 2016) How to dimension safety stock is elaborated on in Section 3.2.4 and 3.3.2.

3.2 Inventory Control

An ICS is employed to establish decision rules about how to manage inventory, such as determining when and how much to order during the replenishment of stock at a distribution network installation. To derive these decision rules, an analytical inventory model can be utilized, aiming to replicate the actual system's behavior. The objective is to identify decision rules that minimize overall inventory costs while meeting company objectives regarding customer service. ICSs can be operated by either using a single-echelon system or by using a multi-echelon system. A single-echelon system consists of only one storage point whereas a multi-echelon system consists of two or more storage points. A basic modeling of inventory systems for a single-echelon model, can be seen in Figure 3.3 below. (Axsäter 2015)

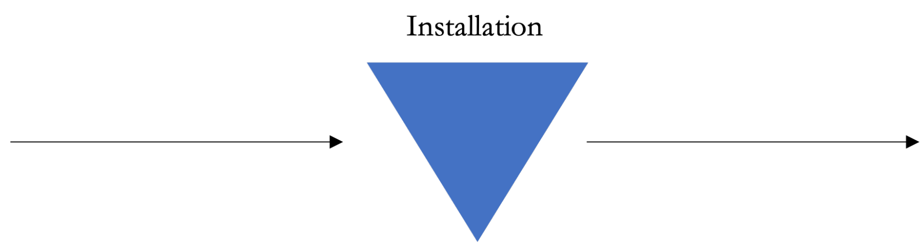


Figure 3.3: Illustration of a single-echelon system.

Inventory control is an important topic for most companies as the overall investment in inventories is substantial and therefore poses significant opportunities for improvement. There are several methods today on how to manage inventory control which can provide competitive advantage. The main purpose with inventory control is to balance between the goals of different business functions. Stock requirements often stem from EOS and uncertainties, but efficient inventory tools can cut costs without sacrificing effectiveness. (Axsäter 2015)

3.2.1 The Significance of Forecasting

An important aspect of ICS is forecasting of future demand to assure adequate quantities are in stock. It is possible to use different methods when forecasting future demand. The forecast is usually based on historical sales data. Methods based on historical data are for example demand models, moving average, exponential smoothing, and regression analysis. Apart from forecasting the future demand it is also important to consider how uncertain the forecast is as well as the forecast error. This can be done by for example using standard deviation of the demand or Mean Absolute Deviation (MAD). (Axsäter 2015)

3.2.2 The Importance of Ordering Systems

An ordering system is the approach to when and how much to order in an ICS. The ordering system should be based on the *inventory position* that is defined as Equation 3.1.

$$\text{inventory position = stock on hand + outstanding orders - backorders} \tag{3.1}$$

Stock on hand is the physical stock, outstanding orders are items that have not yet arrived, and backorders are items that are demanded but not yet delivered, in other words no lost sales exist. Although the ordering system is dependent on the inventory position the costs associated with holding and shortages are based on the *inventory level*, see Equation 3.2.

$$\text{inventory level = stock on hand - backorders} \tag{3.2}$$

Furthermore, to be able to describe when and how much to order, an ordering policy and a review policy is established. (Axsäter 2015)

Review Policy Definition

The review policy establishes whether the inventory position should be reviewed continuously or periodically. A continuous review implies that the inventory position is monitored continuously, and thus an order is triggered instantly when the inventory position is adequately low. The order is delivered after a lead time *L* which means that the total waiting time to replenish the stock is *L*. The advantages with continuous review is that safety stock can be reduced as an order will always be triggered at the same level and thus the ordering point can be adapted to *L*. However, using continuous review makes it more difficult to coordinate orders, hence it is not always supportive of EOS. Therefore continuous review is most suitable for low demand items. (Axsäter 2015)

A periodic review implies that the inventory position is monitored periodically at specific time points. The interval between the reviews is denominated as review period *T*. The order will also be delivered after a lead time L which makes the total time to the next order $T + L$. Since the review is done periodically, there is a risk that the inventory position is far below the ordering point when reviewed. Therefore, periodic review is not suitable for products with high demand fluctuations as this increases the risk of getting stocked out unless the review period is reduced. On the other hand, periodic review is more suitable when aiming for coordinating orders as a new order will always be triggered after the period *T*. (Axsäter 2015)

Ordering Policy Definition

An ordering policy is a policy that establishes when to order and the quantity to be ordered, also called order quantity. There are two main ordering policies denoted as the *(R, Q)* policy and the *(s, S)* policy. (Axsäter 2015)

The *(R, Q)* policy orders a batch of size *Q* when inventory drops below the reorder point *R*. It can also be *(R, nQ)* where n is the number of batches needed. In continuous review, it always hits the reorder point while in periodic review, it often triggers below it, preventing inventory from reaching $R + Q$.(Axsäter 2015)

The reorder point *R* is defined as Equation 3.3.

$$R = m + SS \tag{3.3}$$

, where *m* is the expected demand during the lead time and *SS* is the safety stock. How to calculate the safety stock can be viewed in Section 3.2.4. The batch size *Q*, can be approximated by the economic order quantity (EOQ) which is defined as Equation 3.4.(Axsäter 2015)

$$EOQ = \sqrt{2Ad/h} \tag{3.4}$$

, where *A* is the ordering or setup cost, *d* the demand per time unit, and *h* the holding cost per unit and time unit. After having derived the values of *R* and *Q* the average inventory level (AIL) can be calculated as Equation 3.5 given continuous demand.(Axsäter 2015)

$$E(IL) = R + Q/2 - m \tag{3.5}$$

The *(s, S)* policy orders up to maximum level *S* when inventory drops below reorder point *s*. In continuous review with continuous demand, it is equivalent to the *(R, Q)* policy where *s* = *R* and *S* = $R + Q$. In periodic review or fluctuating demand, *(s, S)* still orders up to $R + Q$, unlike *(R, Q)* which does not. (Axsäter 2015)

3.2.3 Lead Times' Influence on Inventory Management

Lead times in SCs is a key influential variable when it comes to inventory levels. They represent the time interval between placing an order and receiving it. Longer lead times indicate greater uncertainty in demand over that period, leading to higher inventory requirements. Modeling demand typically focuses on the demand arising during lead times, as safety stock needs are directly tied to lead time duration. (Muckstadt & Sapra 2010)

Transchel & Hansen (2019) describe that there are few studies integrating uncertainty in lead times into inventory management of perishable goods with demand fluctuations. Most of the studies consider constant lead times or no replenishment lead times at all. However, through a simulation-based optimization technique, they are able to show that the consequences of assuming constant lead times are either a substantial shortfall in meeting service level objectives or unnecessary waste. Similarly, van der Heijden et al. (1999) emphasize the importance of considering lead time variation upstream, as it profoundly affects the required stock levels to achieve desired fill rates. Fill rate, defined as the proportion of demand met by available inventory, is a critical metric in inventory management, and is described more in detail in Section 3.4.5. Additionally, van der Heijden et al. (1999) stress the significance of examining both supply and demand variation when calculating safety stock in a divergent multi-echelon system.

3.2.4 Calculating Safety Stock

The main factors deciding on the safety stock levels are supply and demand uncertainty as well as desired product availability. Supply uncertainty can depend on multiple factors like delays in production or transportation, and quality issues. Without impacting product availability, decreasing supply uncertainty can significantly lower the safety stock levels. In other words, when calculating the safety stock levels this uncertainty needs to be accounted for. Demand consists of both systematic and random elements, where the random part represents demand uncertainty. Forecasting aims to predict the systematic part and measure the uncertainty, usually with the standard deviation of forecast error. (Chopra & Meindl 2016)

In theoretical models, there are usually a lot of assumptions made when calculating safety stock that do not reflect reality, such as stable demand and continuous monitoring of inventory levels and order points. These potentially incorrect assumptions can result in a lower service level than expected. A common way in the industry to calculate safety stock is to estimate the average demand for a certain number of days. The decided number of days is in turn used as a guideline to determine the size of the safety stock. This approach could lead to a greater difference in service level between different articles compared to if fill rate service had been used instead. (Mattsson 2016*b*)

Mattsson (2016*a*) describes three different methods for deciding on safety stock: proportionality methods, deficiency cost methods, and service level methods. Proportionality methods refer to that the safety stock is proportional to demand while deficiency cost methods is based on estimated shortage costs and minimization of the sum of shortage and inventory holding cost. The last one, service level methods are based on desired service level, which could for example be fill rate or any of the other definitions mentioned in Section 3.4.5. Using the first service level definition (S1) (the probability of no stockout per order cycle) the safety stock can be calculated using Equation 3.6 below.

$$SS = k * \sigma(L) \tag{3.6}$$

, where *SS* is the safety stock, *k* is the safety factor, calculated as the inverse of the normal distribution function for given S1, and $\sigma(L)$ is the standard deviation of the lead time demand. (Axsäter 2015)

When dimensioning safety stock, item classification can be used by differentiating service levels for different items. Mattsson (2016*a*) showed that when using a differentiation based on fill rate service to dimension the safety stock, it can result in reduced tied-up capital. The degree of reduction however depends on the specific company and its order frequency and price structure or it can also depend on the desired service level per order line. The higher the service level, the less reduction of the tied-up capital. However, the differentiation could also lead to increased tied-up capital if the desired service level per order line is high. The differentiation can occur in either one or multiple dimensions, the only difference is the amount of criteria used for the classification of the items. (Mattsson 2016*a*)

Two important managerial tools that can be used to reduce safety stock without compromising availability are either to decrease the supplier lead time or the uncertainty in demand, both of which lead to a reduction in safety stock. However, neither of them is an effortless change. Reducing supplier lead time requires effort from the supplier, but the actual decrease in safety stock happens at the retailer's end. Coordinating the two parties and making sure to fairly divide the resulting benefits is therefore crucial. Decreasing demand uncertainty requires improved market knowledge, enhanced SC visibility, and employment of advanced forecasting techniques. However, the critical element is integrating all forecasts across the SC with customer demand data. (Chopra & Meindl 2016)

Safety Stock of Perishable Items

The relationship between safety stock and perishability is a rather unexplored field of study. Studies in the literature usually treat safety stock and perishability as two unrelated areas. The objective of Yigit & Esnak (2023) is to try to fill this gap by developing a model to compute the overall anticipated waste and associated costs while adhering to a predetermined waste quantity constraint. The final result show that their model perform better than traditional approaches, notably decreasing waste while upholding service levels. Their study therefore concludes that incorporating shelf life into inventory decisions is essential, particularly for items characterized by short shelf lives. In other words, when calculating safety stock it is important to include the factor of perishability of the products.

3.2.5 Main Costs of ICSs

When accounting for ICSs there are three main costs to consider. The first one is the inventory holding cost that accounts for the opportunity cost tied up in inventory as well as costs for material handling, obsolescence, damage, storage, insurance and taxes. This cost is often expressed as a percentage of the unit cost and is much related to the return on an alternative investment. However, it is not equivalent with the expected return as it is important to consider financial risk associated with alternative investments. (Axsäter 2015)

The second cost is ordering or setup costs, which incorporates administrative costs for handling orders as well as setup and learning costs in production. An example of when the setup cost is high is when a capacity constrained machine needs to be stopped during a setup. (Axsäter 2015) Both ordering and holding costs are steady around the economic order quantity (EOQ), which is the optimal lot size. However, it is usually better to order a convenient lot size close to the EOQ rather than precisely at it. (Chopra & Meindl 2016)

The third cost is shortage costs or service constraints which accounts for costs associated with not being able to deliver demanded items. This can lead to the customer choosing another supplier and hence there is a lost revenue that is turned into a cost. It can also lead to loss in goodwill that can affect the company. Even if the customer decides to wait for the item, costs associated with excessive administration and material handling will occur. Apart from these three costs, more specific costs associated with a certain company or situation may occur. This can for example be costs associated with operating the ICS such as costs for data acquisition and computation as well as training. (Axsäter 2015)

In the context of handling perishable products, another significant cost to consider is the expense of waste. As highlighted by Yigit & Esnak 2023 the wastage of perishable products does not only increase costs but also compromises the achieved service level.

3.3 The Purpose of MEICS

MEICS are most common to see when there are numerous installations that are coupled to each other. For instance, when distributing products across extensive geographical areas, several companies employ an inventory system with a CDC in proximity to the production facility and multiple local stocking points near customers in diverse areas. There are several different types of MEICS with different levels of complexity. One common type of MEICS is a divergent system, meaning that the next level of warehouses are higher in number than the previous level. An illustration of a commonly studied divergent multi-echelon system with two levels can be seen in Figure 3.4. The MEICS can also have different functionalities such as assembly, production or pure distribution. (Axsäter 2015)

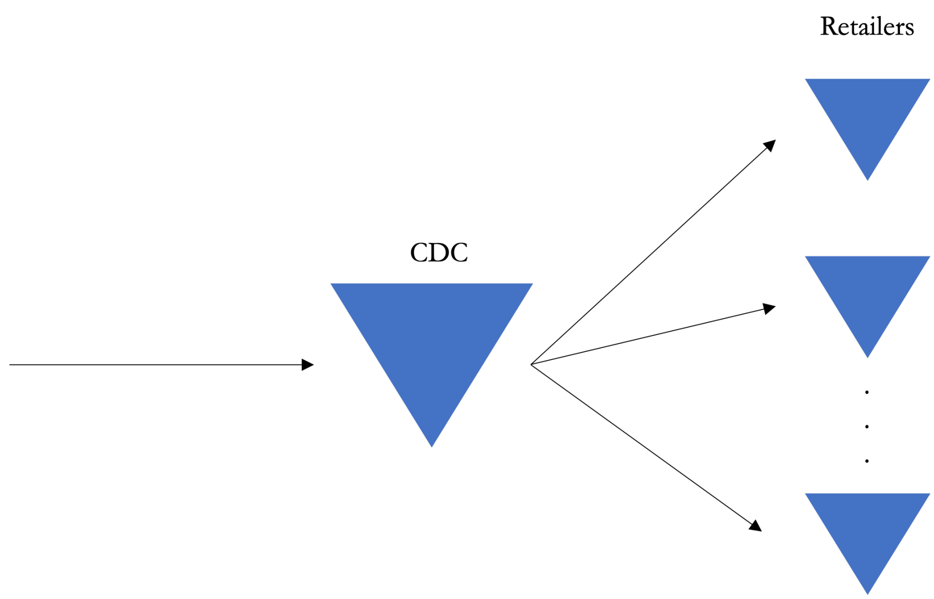


Figure 3.4: Illustration of a divergent multi-echelon system with two levels. (Axsäter 2015)

In order to acquire efficient control of a MEICS it is essential to use certain methods that are responsible for the interdependence between the different stocks. In the case of one single CDC that supports all retailers, having more stock at the CDC results in shorter and less variable lead times for retailers. This, in turn, allows retailers to decrease their own stock levels but at the expense of increased holding costs at the CDC. The optimal allocation of the total system stock depends on the overall system structure, including factors such as demand variations, transportation times and unit costs. (Axsäter 2015)

3.3.1 Policies for MEICS

For most MEICS the structure of optimal policy is complex and thus often unknown. The difficulty lies in determining optimal values of the parameters used in the policy. It is especially difficult to derive a completely centralized policy as it requires a great deal of information to be shared and monitored across the entire system. This is especially true for distribution systems as the storage points are usually widely spread geographically. However, the common ordering policies *(R, Q)*, and *(s, S)* are also suitable to use in the case of MEICS. In the context of multi-echelon inventory control the *(R, Q)* policy is commonly referred to as the installation stock *(R, Q)* policy. It is mentionable that in the case of using these policies, each facility is controlled separately with their own parameter values and not together by one general policy. An alternative method for managing inventory across multiple levels is the echelon stock policy. In comparison with the installation stock *(R, Q)* policy, the inventory position at a particular facility is now aggregated with the inventory position at all downstream facilities. For the review policy it is possible to choose both a continuous or periodic review. (Axsäter 2015)

Defining Material Requirements Planning

Material requirements planning (MRP) is a reorder point system that continuously updates the reorder points based on known discrete requirements. This differs from the reorder point systems based on installation stock and echelon stock where the demand at the various installation stocks is stochastic but remains relatively stable over time. Particularly in production settings, it is common to encounter scenarios where these reorder point systems do not perform very well, and that is where MRP comes in. The principles of MRP can also be applied to distribution systems as product structures resemble MEICS. However, in that case it is referred to as Distribution Requirements Planning (DRP) instead. (Axsäter 2015)

In short, MRP ensures that the right material in the right quantity is in place at the right time. In other words , it manages inventory and production needs usually using periodic review periods. Therefore for planning purposes, some important parameters are lead time, order quantity, and safety stock. The starting point of the process, also called level 0, consists of the end products, in other words the products exclusively subject to external demand. Then level 1 consists of all the direct parts of level 0 and so it continues all the way up to the raw materials. The net requirement of an item is usually to account for the safety stock and backorders. The process relies on specific data for planning purposes, among those a master production schedule (MPS). A MPS spans the total system lead time, from raw material ordering to product delivery, ensuring that production beyond this timeline does not impact current material plans. Other important data are external demands of items not originating from production plans (e.g. spare parts), bill of material which is a list of direct components and their required quantities, inventory status, constant lead times and guidelines for safety stock and batch sizes. (Axsäter 2015)

MRP is advantageous for tracking occasional large requirements efficiently. However, in the case of many higher-level items when more computational effort is required it can sometimes be easier to forecast demand using exponential smoothing and use a less demanding reorder point system. This approach allows for excluding these items from bills of material, simplifying the overall product structures. Another challenge with MRP is something called nervousness, which refers to when plans for specific items change a lot over time which can cause big fluctuations in the plans for smaller items. One approach to counteract this phenomenon is to freeze orders within a certain period of time to ensure that they do not change based on the logic of MRP. (Axsäter 2015)

MRP processes are usually the central focus of a larger planning system, which may also incorporate additional modules such as capacity planning. An Enterprise Resource Planning (ERP) system, which is further described in Section 3.7.1, can be perceived as an expansion of MRP. (Axsäter 2015)

Ordering System Dynamics

Ordering system dynamics encompass the processes and activities associated with managing inventory levels and replenishing stock. The objective is to guarantee that the right amount of inventory is accessible when needed, effectively meeting demand while simultaneously minimizing inventory holding costs. (Axsäter 2015)

Decentralized policies are easy to implement and the installation stock reorder point relies solely on local information. However, one drawback is information delays which can cause significant demand fluctuations at upper echelons despite a stable end demand. This phenomenon is enhanced by substantial order quantities and long lead times, commonly referred to as the bullwhip effect which is further elaborated in Section 3.5.2. (Axsäter 2015)

Centralized policies, like echelon stock, reorder point policies, and MRP, on the other hand, are more complex to implement compared to decentralized ones, as information about the entire system is required. Despite this drawback, there is a growing interest in adopting centralized policies, given the potential high value of more information. However, it is important to note that despite the advances in information technology (IT), the data movement will incur additional costs. (Axsäter 2015)

3.3.2 Safety Stock in a Multi-Echelon SC

In a multi-echelon SC, safety inventory levels at different stages are interconnected. Retailers need to consider both demand and supply uncertainty. The supplier's safety stock levels affect supply uncertainty, impacting the retailer's replenishment lead time. Therefore, adjustments in safety stock levels at one stage can influence those at other stages. (Chopra & Meindl 2016)

Echelon inventory includes all inventory between a stage and the final customer. In multi-echelon setups, reorder points and order-up-to-levels should be determined based on echelon inventory, not just local inventory. Distributors should set safety stock levels considering all retailers they supply. As retailers reduce safety stock, distributors must increase theirs to ensure timely replenishment. (Chopra & Meindl 2016)

In a multi-echelon SC, managing echelon inventory collectively prompts the need to distribute inventory across stages effectively. Upstream inventory aggregation reduces overall inventory needs but may cause customer delays. Decisions on safety stocks depend on cost and customer priorities: higher upstream inventory for cost efficiency, and more downstream inventory for timely delivery. (Chopra & Meindl 2016)

Axsäter (2015) also highlights the complexity and challenges associated with managing safety stocks in a multi-echelon system. When determining how to allocate safety stock, it is important to consider both the total quantity required and how to distribute it among different installations. Allocation decisions depend on various factors, including the system's structure, such as whether it is a distribution or assembly system. In distribution systems, there are typically fewer installations early in the material flow. In general, it is advantageous to allocate safety stocks where there are fewer items with high and relatively stable demand. Therefore, in distribution systems, it is preferable to allocate safety stock early in the material flow. Another characteristic influencing safety stock allocation is lead times. In distribution systems where DC lead times significantly exceed retailer lead times, it is advisable to maintain a larger portion of stock at the DC.

3.4 Performance Evaluation for Inventory Management

3.4.1 Performance Measurement and Management System Definition

A management dashboard, also called a performance measurement and management system (PMS) is a collection of performance indicators that assess how effectively and efficiently actions are being carried out. Its primary goal is to support informed decision-making by gathering, merging, analyzing, and understanding relevant data. (Biazzo & Garengo 2012)

Furthermore, a PMS should function as a balanced and strategic system. A balanced system means that the system should offer a balanced perspective, providing a comprehensive understanding of how the company operates. This includes not only financial metrics but also aspects such as customer and supplier relationships, innovation processes, and the alignment of human resources with predetermined competence profiles. A strategic system, on the other hand, involves carefully selecting indicators based on identifying critical success factors (CSFs). These CSFs represent the qualitative aspects of a company's strategic decisions, in other words, guide a business toward securing a distinct position within its industry and leveraging internal resources and capabilities. When it comes to identifying strategically aligned performance measures the identification of CSFs is an important first step. Emphasizing trade-offs when identifying the main logical connections between CSFs is essential as improving certain aspects may worsen others. In such cases, it is crucial to find the optimal balance between the CSFs. (Biazzo & Garengo 2012)

Even though technology makes it easy to gather lots of data today, a PMS is more than numbers and reports. Simply having lots of data does not make it a useful "management dashboard", it can often confuse things rather than improve decision-making. A strong dashboard connects indicators with CSFs, providing the foundation for setting performance targets and making decisions about initiatives and investments. (Biazzo & Garengo 2012)

3.4.2 Characteristics of a PMS

A PMS has various characteristics which are described by Biazzo & Garengo (2012). However the ones that are deemed to be of relevance for this thesis are the following: strategy alignment, casual relationships, and transparency and simplicity.

Strategy Alignment

To connect a company's strategy with the goals of departments, teams, and individuals, a PMS should be designed in line with the business strategy. In traditional models, the lack of alignment between performance measurements and business strategy is a key obstacle to achieving expected results from a PMS. The alignment between business strategy and PMS is emphasized by models proposed after the mid-1980s, such as the balanced scorecard (BSC), a model that is described further in Section 3.4.3. (Biazzo & Garengo 2012)

Casual Relationships

A PMS should assess both results and determinants, this because performance measurements aim to help with planning and control. In order to monitor past actions and improvements processes, the PMS should also quantify the "causal relationship" between the results and determinants. Gaining insights into the connections between results and determinants allows for regular feedback on measures, performance, and changes. However, these connections can be rather complex and therefore also challenging to analyze. (Biazzo & Garengo 2012)

Transparency and Simplicity

For the successful implementation and utilization of a PMS, transparency and simplicity are crucial characteristics. To assess whether a PMS is transparent and simple the following components can be used as guidance: the set goals are clearly defined and communicated, the measures chosen are carefully selected and defined, how to collect and process data is clearly defined, usage of relative measures and not absolute, and the presentation format of the processed information is specified. However, it is important to acknowledge that ensuring the simplicity and user-friendliness of a PMS should not come at the expense of system completeness. (Biazzo & Garengo 2012)

3.4.3 The Concept of BSC

The BSC is the most widely recognized and comprehensible reference model of a strategic and balanced dashboard. Kaplan and Norton introduced the fundamental concepts of BSC in a well known article published in the Harvard Business Review in 1992. (Biazzo & Garengo 2012)

The BSC model advocates for a balanced assessment of business performance across four perspectives: financial, customer, business processes, and human resources. All of the perspectives are linked to each other. Human resources constitute the foundation pillar on which the other perspectives depend. The financial perspective is at the top and depends on all the other perspectives to be effective and efficient. By illustrating CSFs across these four perspectives, the strategy map visually outlines how an organization aims to deliver value to its stakeholders, offering insight into the rationale behind the business strategy and explaining the measures incorporated in the BSC. (Biazzo & Garengo 2012)

When creating the indicators for the dashboard there are some helpful guidelines for each of the perspectives that one can take advantage of. From a financial perspective, the measures can be divided into three categories: summary measures of financial results, productivity/efficiency measures, and growth measures. Performance measures from the customer perspective should be built upon a thorough comprehension of the target customers and the value proposition offered to them. Three components outline the value proposition: product/service attributes, custom relationships, and image and reputation. This basic idea of the value proposition helps identify a company's CSFs. The three key process performance areas are efficiency/productivity, output quality, and service. Finally, from the perspective of human resources, it is important to comprehend three aspects of the person-enterprise relationship: (i) what people do, (ii) how they feel, and (iii) what they know. In terms of the first aspect, absenteeism rates, turnover, and settlement extent can indicate how people behave towards the organization, reflecting their satisfaction with their job. Regarding the second aspect, corporate climate and culture surveys aim to understand how people feel about important aspects of an organization's success. The last aspect includes assessing competencies to meet the company's goals. (Biazzo & Garengo 2012)

Not to be forgotten when using a BSC in practice is that a BSC is based on the existence of data and a navigation system. Business Intelligence (BI) software, is an advanced form of navigation system that enables users to conduct complex analyzes over time by automating data aggregation and integration. BI transforms the BSC into a practical tool for strategic control. However, difficulty in identifying Key performance indicators (KPIs) may lead to the risk of the dashboard becoming merely a reporting tool, undermining its benefits in enterprise management. (Biazzo & Garengo 2012)

3.4.4 Importance of KPIs

KPIs play a crucial role in enabling organizations to track their progress and ensure efficient achievement of business objectives. The KPIs provide an analytical foundation for decision-making and contribute to both strategic and operational enhancements. (Singh et al. 2020)

When dealing with a complex SC it can be challenging to reach consensus on appropriate measurement dimensions. Therefore it is important that the measurement metrics are aligned with the firm's strategy, tailored to the specific department or companies, adaptable to changing circumstances, straightforward, provide prompt feedback and foster continuous improvement. (Gebisa 2023)

3.4.5 KPIs for Inventory Control

In regards to inventory control, the primary objective is to satisfy customer demand while at the same time not keep too much in stock. Two commonly used KPIs that can be used for inventory management are inventory turnover rate and service level. (Singh et al. 2020)

Service Level as KPI

The availability of food products can affect how much is sold in other food categories, a concept referred to as cross-selling. To have a service-level approach is therefore of great importance when it comes to managing food product inventory. (Minner & Transchel 2010) Given that the thesis focuses on a multi-echelon inventory system, the significance of employing an appropriate service level approach is underscored by the fact that service levels are interconnected across levels (Rosenbaum 1981).

Product availability, also known as customer service level, plays a crucial role in assessing SC responsiveness. Higher product availability enhances responsiveness, attracting customers and boosting SC revenue. However, finding the balance between availability and inventory costs remains a consistent problem. (Chopra & Meindl 2016)

The optimal product availability level is influenced by the cost of overstocking and the cost of understocking. Overstocking costs represent the expense a company faces for each unsold item remaining at the end of a selling period while understocking costs reflect lost profits from missed sales due to insufficient inventory. In the case of understocking of continuously stocked items, the two extreme scenarios are either a backlog or being counted as a loss sale. Therefore, integrating uncertainty into decisions and when determining the right product availability level can enhance profits compared to relying on standard forecasts. (Chopra & Meindl 2016)

Other influential factors mentioned by Mattsson (2016*b*) are order frequency and order quantities. Mattsson (2016*b*) finds that low customer order (CO) frequency increases variations in achieved service levels. Additionally, inadequate consideration of stock withdrawals exceeding one unit exacerbates the difference between desired and achieved service levels, especially with lower order frequencies. Additionally, Mattsson (2016*b*) highlights order quantity as a determinant of achieved service levels, noting that lower order quantities result in greater safety stock but lower capital tied up in cycle inventory.

When it comes to enhancing the service level KPI Singh et al. (2020) mention methods like calculating forecasts, establishing specific service policies for each item, and maintaining safety stock to address any urgent situations. These approaches contribute to maintaining a satisfactory level of product availability while effectively managing inventory costs and maximizing profitability.

In practice when determining optimal product availability levels it is important to acknowledge that many companies set availability levels without clear justification. It is therefore essential to question these presets and adjust them to maximize profits. (Chopra & Meindl 2016)

Service Level Definitions

Service level assesses the likelihood of meeting demand without backorder or sale loss over a specific time period. (Singh et al. 2020) However, the interpretation of service level may differ among companies. Axsäter (2015) defines service level in three different ways:

1. The probability of no stockout per order cycle
2. Fill rate - fraction of demand that can be satisfied immediately from stock on hand
3. Ready rate - a fraction of time with positive stock on hand

The first definition, also referred to as cycle service level (CSL), is also mentioned by Chopra & Meindl (2016) and Cardós et al. (2009) as a common way to measure service level. Given that the stock level is known at the start of the cycle, the definition is applicable to any inventory policy and pattern of demand according to Cardós et al. (2009). However, a drawback of this approach of measuring described by Cardós et al. (2009) is that it does not consider demand fulfillment. An improved definition of CSL presented by Cardós et al. (2006) takes into account the probability of demand during the review cycle being both positive and less than the stock available at the onset of the cycle. The advantages of this definition are according to Cardós et al. (2009) that it includes demand in the measurement, it does not overlook shortages at order points, and also it works correctly even if the demand during the replenishment cycle is zero.

The second definition mentioned by Axsäter (2015), fill rate, is also mentioned by Chopra & Meindl (2016) as well as Mattsson (2016*b*) but in different aspects. Chopra & Meindl (2016) mention product fill rate and order fill rate, which refers to the percentage of product demand or orders met by inventory, respectively. Conversely, Mattsson (2016*b*) aligns with Axsäter (2015) definition of fill rate while also introducing the notion of order line service, measuring the proportion of order lines directly fulfilled from available stock. Mattsson (2016*b*) describes how fill rate is typically used when it comes to calculating safety stock, while order line service is more used in industry to measure actually achieved service level. Further, he reports that if all CO quantities are one unit the fill rate and order line service would be equal. This could for example be the case for expensive products with low demand. However, this is rarely the case, so if a specific fill rate is used when calculating for safety stock, the achieved order line service is nominally less. Mattsson (2016*b*) finds through simulations that the achieved fill rate is also, on average, lower than planned.

The third definition, referred to as the ready rate, assesses the probability that an item is free from backorders when observed randomly at any moment. It is a binary measure, indicating the presence or absence of backorders. The ready rate is always as good as or better than the fill rate. When there are no backorders, both rates are zero. But if the demand is low and the lead time is short, the ready rate could be close to one. However, a drawback with ready rate is that it does not consider how long backorders last when they happen, which also applies for the calculation of fill rate. A high fill rate or ready rate does therefore not always imply fully meeting the needs of the customers. (Muckstadt & Sapra 2010)

Something that all three service level definitions of Axsäter (2015) have in common is the assumption of infinite product lifetimes, which may be important to consider in the case of perishable goods. However, regardless of which definition is applied, it is crucial to ensure a consistent definition throughout the entire organization. Additionally, having the capability to monitor actual customer service based on the established definition provides further benefits. Furthermore, it is generally not suitable to apply the same target service level to all stock-keeping units (SKUs). To address this issue effectively, it may be necessary to segment products based on their characteristics and assign similar target service levels to SKUs within each segment. (Axsäter 2015)

Inventory Turnover Rate as KPI

Inventory turnover rate reflects the frequency of inventory utilization within a company over a specified time period, typically a year. (Singh et al. 2020) It is usually calculated by dividing the cost of goods sold by the average inventory (Jama et al. 2023). According to Rossi (2021) one can also use the implied turnover ratio, which is calculated by dividing the average demand by the average inventory. Optimizing inventory turnover rate involves enhancing the pace at which inventory items are sold and replenished to efficiently meet customer demands. (Jama et al. 2023) Possible actions that can help improve the inventory turnover rate is to categorize the items based on different factors such as consumption, demand, and procurement cost. (Singh et al. 2020) Other strategies for optimization that Jama et al. (2023) describes include selling slow-moving inventory at discounted prices to stimulate sales. Inventory turnover rate serves as a critical performance measure, reflecting the flow of products to customers. In other words, it indicates how quickly inventory is converted into receivables through sales. (Jama et al. 2023)

3.5 The Essence of SC Collaboration

Multiple researchers have found that SC collaboration exerts a significant impact on SC performance. SC collaboration refers to the cooperation between one or more companies or business units to create mutual benefits (Spekman et al. 1998) and incorporates joint performance measurements, information sharing, decision synchronization, and incentive alignments (Simatupang & Sridharan 2008). The incorporation of joint performance measurements is detailed in Section 3.4.2, while incentive alignments , information sharing and decision synchronization is further explained below in Sections 3.5.1 to 3.5.3. Ghasemi et al. (2023) states that the focal point of these SC relationships lies in the inventory management activities. Business success depends in many cases greatly on the effective management of inventory. According to Min et al. (2006) good collaboration leads to improved SC performance regarding efficiency, effectiveness and profitability, and Simatupang & Sridharan (2005) indicates that a bad performing SC is usually caused by challenges in SC collaboration.

3.5.1 The Impact of Incentive Alignments on SC Performance

Aligning incentives within a company is crucial for ensuring high product availability at minimal cost and asset investment (Stank et al. 2011). When individuals prioritize their private agendas over the collective goals, SC members fail to reach their full potential due to the conflicting interests. Consequently, inefficiency losses such as excessive inventories, stockouts, markdowns, and resource misallocation become prevalent within the SC. (Simatupang & Sridharan 2005). Within inventory management de Vries (2013) shows that different stakeholders' perceptions of the inventory management system affect the outcome of its performance. The reason is that stakeholders usually try to serve their own interests and power positions, and thus it is important to have strategies for how to handle opposing interests. Incentive alignments is in other words an important aspect of a well performing SC.

A commonly used term in the discussion of incentive alignment is strategic fit, which refers to the alignment between a company's competitive and SC strategies, ensuring shared goals. To achieve a strategic fit, mainly three things must be accomplished. Firstly, all functional strategies and the competitive strategy must all be aligned and complement each other. Secondly, processes and resources need to be organized effectively across the different functions. Lastly, the design and roles within the SC must uphold the SC strategy. Failure may occur due to either a lack of strategic fit or if the SC structure fails to support the desired strategic alignment effectively. (Chopra & Meindl 2016)

Despite the recognized importance of incentive alignment, its actual implementation often falls short. This challenge stems from the difficulty of translating aspirations for alignment into actionable practices, which requires defining effective incentives that guide practitioners' behavior toward desired outcomes (Norrman & Näslund 2019). Ellinger et al. (2006) underscores the complexity of finding aligned incentives, attributing it to the poorly understood nature of cross-functional integration and collaboration. Furthermore, Ellinger et al. (2006) reveals that different functions in a company may have misunderstanding perceptions of each other, leading to mistrust and affecting confidence in each other's work. Thus, while incentive alignment is vital for improving SC performance, it remains challenging to implement, incorporating both technical and social factors.

3.5.2 The Relevance of Information Sharing

When studying inventory control, information sharing is an important aspect to consider. Information sharing can be used to mitigate the bullwhip effect (Constantino et al. 2014), reduce inventory levels, increase availability (Yuan & Qiong 2008), and improve firm performance Gebisa (2023).

Various researchers such as (Lee et al. 1997), Constantino et al. (2014), and Barlas & Gunduz (2011) link the bullwhip effect to bad information sharing. The bullwhip effect is a phenomenon characterized by distortion of demand information as it travels upstream, leading to excessive inventory levels at various points in the SC. It is common to see in MEICS and can be a reason for lackluster SC performance. According to Lee et al. (1997), the bullwhip effect often starts with demand forecast updating which typically involves misinterpreting signals. For instance, fluctuations in current demand are often mistakenly seen as predictors of future demand shifts. By sharing downstream demand data with upstream nodes, the upstream nodes can more accurately adjust inventories and thereby mitigate the bullwhip effect. Technologies that can be used for this are Electronic Data Interchange (EDI) and Vendor Managed Inventories (VMI). Constantino et al. (2014) and Barlas & Gunduz (2011) also demonstrate that sharing end customer demand data positively impacts the bullwhip effect. Constantino et al. (2014) compares six levels of information sharing, and concludes that optimal SC performance in regards to the bullwhip effect occurs when all echelons have access to end customer demand data. While any information sharing between echelons is beneficial, downstream collaboration proves more effective than upstream collaboration since it is easier to prevent the bullwhip effect compared to stopping it. Barlas & Gunduz (2011) considers different ordering policies in a three-echelon SC and finds that isolated demand forecasting performed at each echelon is a major cause of the bullwhip effect. By sharing end customer demand and forecasting, the bullwhip effect can be reduced significantly. There is hence no doubt, researchers agree that sharing of end customer demand data across the SC is crucial for combating the bullwhip effect.

Other SC improvements linked to information sharing are decreased inventory levels, increased availability, improved inventory management practices, and improved firm performance. Constantino et al. (2014) shows how sharing end customer data will, apart from mitigating the bullwhip effect, also result in overall lower inventory levels and improved availability. The same pattern as for the bullwhip effect follows - optimal inventory levels and availability occur when end customer demand is accessible in all echelons, downstream collaboration is more effective than upstream collaboration but any information sharing is better than none. Yuan & Qiong (2008) supports Constantino et al. (2014) findings that sharing information on customer demand affects inventory levels and availability in a positive manner. However, they also stress the fact that information sharing is not always easy to motivate as members in the SC might be fearful of sharing sensitive information. To overcome this it is suggested that pricing discounts, order incentives, buy-back, cross-shareholding, and revenue distribution are good techniques to motivate the parties to share information. Apart from inventory levels and availability, Gebisa (2023) suggests that information sharing can lead to improvements in inventory management practices such as improved efficiency, accuracy, and responsiveness. This in turn affects overall firm performance such as customer satisfaction, operational efficiency, and financial performance positively. Hence, information sharing is not only good for mitigating the bullwhip effect but can have positive effects on inventory management in general as well as overall firm performance.

Customer demand data is undoubtedly crucial data to share, but various data can have different degrees of influence on enhancing SC performance when sharing it and therefore it is paramount to share the right information across the SC. According to Jonsson & Mattsson (2013) it is the demand type that affects which data that is most effective to use. With a steady demand, sharing stock-on-hand data across the SC helps decrease inventory levels while sharing planned order data instead increases them. The increase in inventory levels is explained by system nervousness which occurs when MRP principles, such as what, when, and how much of a material is needed, generate upstream variation demand. With seasonal demand, the same trend follows but with an even larger increase in inventory when sharing planned order data. For promotional demand, it is more effective to share customer forecast data and planned order data since it gives indications of when promotions will occur. Point-of-Sale (POS) data have, according to Jonsson & Mattsson

(2013), no effect on inventory levels in any of the cases. The low effectiveness of sharing POS data is strengthened by Abolghasemi et al. (2023) who investigates how POS, order series, and order-based information sharing affects the accuracy of forecasting in a fast-moving consumer goods (FMCG) multi-echelon SC. According to their findings, order series and order-based information sharing outperform POS data when using the most suitable forecasting method for the system. However, they find POS data to be effective when there is a promotional demand which contradicts Jonsson & Mattsson (2013) findings. It is acknowledged in Jonsson & Mattsson (2013) study that POS data has been found to be effective by many researchers. Jonsson & Mattsson (2013) believe that the findings of their own study are affected by the distribution setup. They believe that a distribution network with more echelons and longer lead times than the one they are studying, might have more benefit from POS data. As Abolghasemi et al. (2023) studies a large grocery retailer the prerequisites might therefore resemble the larger network and thus the findings of POS data being effective when there is a promotional demand is reasonable. Nevertheless, it is clear that different SCs respond differently to different types of information sharing. Therefore it is important to acknowledge the prerequisites before deciding on which data to use.

Information Sharing in Perishable Goods SCs

Information sharing in a SC of perishable goods is complex as there are more parameters to consider such as shelf life, vulnerability, and criticality of the product. Lusiantor et al. (2018) conducts a systematic literature review (SLR) that identifies inadequacies in what the literature says about the topic. The conclusion of the SLR is that reality is more complex than theory suggests, thus more research is needed. However, even though the theory might be inadequate in its findings, there seems to be a consensus that information sharing has a positive impact on perishable goods SCs. Clements et al. (2008) suggests that information sharing in SCs of perishable goods can reduce the complexity and facilitate procurement, purchasing logistic, and information. According to Ferguson & Ketzenberg (2006), sharing information on expiration dates in a SC can decrease operational costs but is mostly beneficial for products where demand varies greatly, the shelf life of the product is short, or the cost of the product is high. When looking at waste reduction, Kaipia et al. (2013) identifies that more efficient information sharing can improve the SC performance of perishable goods. Consequently, literature indicates that information sharing has a positive impact on the aspect of perishable goods, but there might be inadequacies in how, when, and what information should be shared. However, it is crucial to underscore that food past its use-by date are not allowed to be sold or utilized by restaurants. Sharing the expiry date is therefore a mandatory requirement. Livsmedelsverket (2024)

3.5.3 The Role of Decision Synchronization in SCM

Decision synchronization in SCM involves SC partners coordinating joint decisions to optimize planning and operational strategies, resolving conflicts and disagreements. It includes collaborative processes for decision-making and the reallocation of decision-making authority to coordinate SC planning and execution, aiming to align demand with supply. In SC, critical decisions like for example inventory management, order placement and customer service levels require collaborative decision-making among partners to optimize resources and achieve objectives. Joint planning facilitates operational decisions related to inventory replenishment, delivery scheduling, and inventory management to mitigate the bullwhip effect. (García-Alcaraz et al. 2021)

Effective decision synchronization enhances SC performance and profitability by aligning partners and improving decision timing to meet customer demands and SC objectives. Collaboration among partners is crucial for evolving SC business practices from mere cooperation to genuine collaboration. Collaborative relationships within the SC enable the assessment of information flow, enhancing SC capacity through synchronized decision-making, thus fostering agility and flexibility. (García-Alcaraz et al. 2021)

3.6 Maturity Evaluation

3.6.1 SCM Maturity Definition and Assessment

Supply chain management maturity (SCMM) is a way of assessing how developed a company is regarding the business process orientation and business process management. To know the level of the SCMM helps SCM managers with guidance and directions on how to move forward with the business. (Bach et al. 2023) Knowledge of a company's level of SCMM can also help increase the service level as it facilitates knowing how to add value along the value chain (Chang et al. 2013). A higher level of SCMM is found to reduce inventory levels and costs while at the same time increase on-time delivery (OTD) rates (Qrunfleh & Tarafdar 2014). Bach et al. (2023) also finds that increased SCMM has a positive impact on overall business performance in relation to the BSC, especially in industries where technology is prominent.

The SCMM of a company can be assessed in different ways, but all is converging on the same essence. The supply chain process management maturity model (SCPM3) serves as a comprehensive maturity model, evaluating whether a company is in the maturity level Foundation, Structure, Vision, Integration, or Dynamics. A company in the Foundation level (lowest level) of SCMM has identified its key business partners and uses best practice for order management, but has still not stabilized and documented all its processes. The process flexibility is slow and costly and bad integration between business functions leads to insufficient consideration of production capacity and inventory. The IT systems do not support all the SC processes. A company in the Dynamics level (highest level) of SCMM is strategically integrated with its partners in the SC and facilitates its collaboration through high flexibility and responsiveness to the market. The collaboration between sales, marketing, distribution, and planning is well developed, and demand management and production planning scheduling are integrated. KPIs are set and monitored in a way that aids the business to improve its performance. The intermediate levels between Foundation and Dynamics are moving away from the Foundation and towards Dynamics by structuring the business processes and becoming more integrated. This transition implies a maturation process aimed at improving the SC performance. (Bach et al. 2023)

3.6.2 Technological Maturity Definition and Assessment

Another type of maturity that is important to consider in the context of inventory control is the technological maturity of a company. In the era of Industry 4.0, numerous advanced technologies exist, capable of fostering intelligent and interconnected manufacturing and SC systems. While these technologies offer substantial benefits, the actual implementation poses a significant challenge for many companies. It is therefore of great importance that companies evaluate and position their level of digital maturity. (Tiss & Orellano 2023)

To assess whether a company is technologically mature or not, a maturity model can be used. Tiss & Orellano (2023) suggests a model that considers the three dimensions technological, user experience and organizational. The technological dimension defines the company's current state of technological advancement and incorporates the data collection, data analysis, data exchange and process management. The user experience concerns customization of tools (in other words if the systems used fulfills the company's personal needs) , change management, and ergonomics (how many applications users need to manage). The organizational dimension focuses on the internal structure and global strategy of a company to manage and perform its activities and incorporates business process standardization, human resource strategy, digital culture, and decision-making alignment. By conducting a guided questionnaire within these areas, the company's technological maturity can be assessed on a scale from 1-5 where one is non-existent technological maturity and five is excellent technological maturity.

3.7 IT in Inventory Management

IT encompasses hardware, software, and personnel across the SC. IT plays a crucial role when it comes to acquiring, analyzing, and acting upon data to enhance SC efficiency, not least within inventory management. (Chopra & Meindl 2016)

There are many technologies that can be utilized for sharing and analyzing information. One first example is electronic data interchange (EDI) which enables fast electronic placements of purchase orders with suppliers. Another important technology is the Internet. Compared to EDI, the Internet transmits significantly more information through standardized infrastructure and has become the primary communication medium across various SC processes, facilitating efficiency and responsiveness from suppliers to customers. The information displayed by the Internet can then be managed by an enterprise resource management (ERP) system. ERP systems are further described in Section 3.7.1. Based on the real-time information that an ERP system provides, SCM software can support a company in the optimal actions to take and enhance information visibility. (Chopra & Meindl 2016)

The establishment of inventory restocking methods, enhanced inventory visibility and improved SC coordination are three major benefits offered by IT systems. However, important to acknowledge is that an IT system's effectiveness is dependent on accurate inventory records. Furthermore, IT systems are vital for success, but they alone are not adequate. Organizational changes and strong leadership commitment are equally crucial factors in achieving success. (Chopra & Meindl 2016)

3.7.1 ERP Systems in Inventory Management

ERP is an information system that uses IT as its medium to store data within a database. The objective of an ERP is to facilitate decision-making by gathering and storing important information for a company in one common place. The management culture of the company serves as a core for the ERP, as the iNeed Plannerut data provides output data for the decision-making. (Zhao & Tu 2021)

Today ERP systems is the mainstream tool to improve inventory management(Zhao & Tu 2021). According to Lim et al. (2023), many enterprises use IT systems to handle their inventory management mainly to reduce costs and increase efficiency. ERP represents an evolved iteration of MRP and offers diverse functionalities to streamline inventory management. It can for example help with main production/distribution planning, procurement planning and sales planning. Through its capabilities in planning and control, ERP standardizes processes and refines management. (Zhao & Tu 2021) Furthermore, ERP serves as a catalyst for fostering cross-departmental business planning and facilitating information sharing (Tsai et al. 2011), both of which are important to improve inventory management practices. (Zhao & Tu 2021)

With the facilitation and automation of numerous tasks by ERP systems, the need for employees to perform pure transactional tasks diminishes. Instead, there is a greater pressure on hiring technical personnel capable of maintaining and managing the system effectively (Zhao & Tu 2021), which can be challenging (Lim et al. 2023). Moreover, given that ERP systems encompass substantial business logic, it becomes crucial to have employees who possess proficiency in both business operations and ERP functionalities (Zhao & Tu 2021). According to Tsai et al. (2011), a business's performance increases if the enterprise conducts knowledge maintenance, meaning that the employees are continuously being updated on how to effectively operate the company's ERP. This is strengthened by Zhao & Tu (2021) who mentions that since the environment of ERP is updated regularly, employees need to learn how to quickly adapt to changes. This can also be challenging as there is often resistance to change among employees which can pose a hindrance in utilizing ERP's full potential. (Lim et al. 2023)

Chapter 4

Mapping of MEICS

This chapter provides an in-depth analysis of the case company's MEICS. It starts with an overview in Section 4.1, followed by detailed descriptions of the ERP and transportation systems utilized in Sections 4.2 through 4.3. Section 4.4 elaborates on the primary variables influencing inventory levels within the case company, while Sections 4.5 through 4.6 outline the approaches employed for managing shelf life and stockouts. The chapter ends with an exploration of the KPI measurement system in Section 4.7.

The mapping of the Company's MEICS is based on archival records as well as the first round of interviews with the following interview objects: a *Delivery Planner*, an *Acting Solution Owner*, a *Business Navigator*, a *Project Leader* and a *Development Manager*. The interview guide can be found in Appendix A.1. The mapping is limited to the flow between the CDC and RDCs, and specifically the RDC in Parma. The mapping starts with an overview of the MEICS and then goes into detail on the different components. The mapping is purely descriptive with only a few small reflective comments. A more in-depth analysis can be found in Section 5.

4.1 Overview of the MEICS

The Company has a divergent two-level inventory system, as previously described in Section 1.2. The primary objective of the inventory system is to maximize product availability while minimizing costs to the greatest extent possible. The MEICS is centralized and primarily overseen through an ERP system named M3. A team of employees is tasked with specific responsibilities for various inventory management activities, ensuring effective execution across the system. The foundation of the inventory control is an MRP, which is further explained together with M3 in Section 4.2. An MRP is created for each DC and employees use the information in the MRP to perform activities linked to the inventory control.

According to the interviewees, the inventory levels at the DCs are mainly influenced by the following variables: retailers' demand, safety stock, and demand forecast. Safety stock is in turn affected by lead times and customer demand variability which is further described in Section 4.4.2. Further, since the Company maintains a food inventory, shelf life emerges as another critical variable for consideration. The mentioned variables is described more in detail in Sections 4.4 and 4.5.

The process of inventory control between the CDC and RDCs starts with retailers placing an order in the customer interface called E-shop which is connected to M3. Based on the demand from the retailers, M3 creates a proposal for a distribution order (DO) of items that need to be replenished in the RDC and sends it to the MRP of the CDC. According to the interviewees, the Company have quite stable customer demand, meaning that it is rather foreseeable over time with known variations. Further, the lead time from when an order is picked and packed at Helsingborg until it is received at Parma is described as constant and therefore set static to four days in M3. The DOs are monitored by employees who most of the time release the proposed orders generated by M3. However, if the DO is not possible due to stock out at the CDC the one responsible for the order will make necessary changes to the proposal. See Figure 4.1 below for a simplified illustration of the inventory control process between the CDC and RDCs.

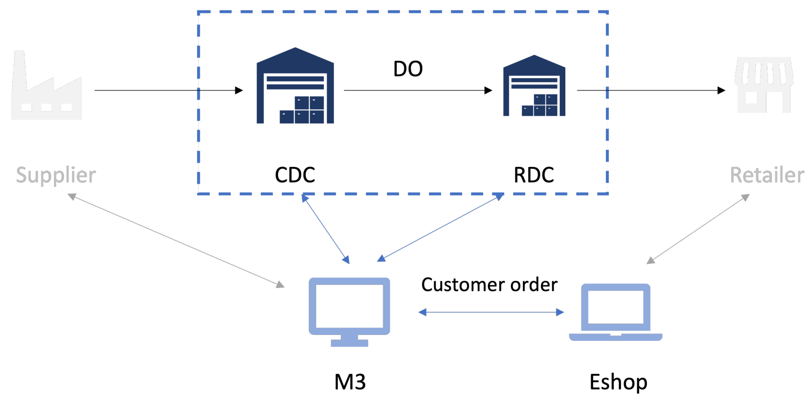


Figure 4.1: Simplified illustration of the Company's MEICS.

4.1.1 Roles and Responsibilities

There are mainly four important roles involved in the inventory control process between the CDC and RDCs: Demand Planner, Delivery Planner, Need Planner, and Service Provider Operations Development (SPOD).

- *Demand Planners* are responsible for the demand forecasts in M3.
- *Need Planners* are responsible for deciding what inventory levels to hold of the various items at the different DCs which incorporates calculating safety stocks.

- *Delivery Planners* are responsible for the distribution of goods between the CDC and the RDCs. Their main tasks are to monitor transportation and plan for DOs, but also maintain the inventory levels decided by the Need Planner.
- *SPODs* are responsible for making decisions regarding which of the distribution flows described in Section 1.2 to use. They make decisions manually by weighing volume, distance, and cost of transportation against each other to try and find the best alternative.

All of these roles have divided responsibilities and there is not much discussion and exchanges between them. In other words, the roles operate with a silo mindset which can be a sign of misaligned objectives. According to theory, misaligned objectives can pose a significant obstacle to achieving expected KPI results and thereby hinder overall business success.

4.2 The ERP System Used

The ERP system used for the inventory control is provided by Infor and is named M3. M3 is a cloud based ERP system within manufacturing and distribution that can be adapted to specific industries (Infor 2024). The Company uses a single-tenant cloud version of M3. However, the Company updates the system regularly and has added its own modifications to the system by changing the source code when needed.

Apart from M3, the Company uses several external systems to create a total solution. One important system for the distribution and inventory management between the CDC and RDCs is Load Planner which is further described in Section 4.3. The other systems are used for customer and supplier interaction, KPI analysis as well as administration. Customer and supplier interaction, and administration is seen as out of scope for this master thesis. KPI analysis is described in Section 4.7.

The Company's business systems are not connected to the retailers who work independently, hence the Company has no information regarding the retailers' inventory levels, customer demand, replenishment policies, etc. According to theory, collaboration such as information sharing is key to maintain efficient inventory control, especially regarding end customer demand data. Thus it is a flaw that the Company's MEICS does not have access to retailer data.

Another interesting aspect is that ERP systems are catalysts for cross-departmental collaboration and internal information sharing, see Section 3.7.1, still the Company express a silo mindset within the organization.

4.2.1 MRP for Reordering Point Calculations

The Company uses an MRP as its reordering point system. To use an MRP for calculations of reordering points is a rather simple system as it assumes constant lead times and does not consider stochastic events in the demand, see Axsäter (2015) in Section 3.3.1. However, as the Company's lead times and demand are described by themselves to be rather foreseeable with known seasonal variance, see Section 4.4.2 and 4.4.1, an MRP can be sufficient to use.

The MRP, as described by the interviewees, is a list of all the historical and prospective transactions created by M3 and ensures that orders are delivered before inventory levels fall below the predetermined safety stock. By using fixed lead times, forecasted orders and information about transactions performed during the day, the MRP updates the inventory levels each night and creates proposals for DOs frequently. Once the DOs are approved, they become fixed orders. The proposals are hence done automatically in M3, but the Delivery Planner can manually change the proposals if considered necessary before approving them. Reasons for changing the DOs are for example if the CDC in Helsingborg does not have enough items in stock. Every evening, a stock report from the CDC is released, which serves as the foundation for the Delivery Planner's assessment of whether the suggested DOs can be met or if there is a shortage in goods available. The handling of stock outs is further described in Section 4.6.

In the MRP the forecasted orders is replaced by the fixed orders once the DO is approved. By changing a control parameter in M3 called the *Demand Time Fence*, it is possible to decide over which time horizon fixed orders should be prioritized over the forecasted ones. When deciding when to set the Demand Time Fence it is important to not set it too early or too late. If the fixed orders are placed too far in advance it is more difficult to adapt to demand at the retailers, but if it is set too soon, the right quantity will not arrive on time.

It should be mentioned that theoretically, as a distributing company, the Company's MRP aligns more closely with a DRP (Distribution Requirements Planning) system. However, since the Company themselves refer to it as an MRP, for consistency, this thesis will also refer to it as an MRP. Similarly, the Company does not utilize a traditional MPS (Master Production Schedule), but rather a Master Distribution Schedule (MDS) that plans for DOs.

4.2.2 Segmentation of Products

All items are segmented within M3 mainly based on storage requirements, target service levels, and market regulations.

Storage Requirements

The food items need to be segmented based on storage requirements in terms of temperature zones. The zones marked in M3 are frozen (FR), chilled (CH), ambient (AM), and dry (DR). Further, products containing alcohol above a specific threshold must adhere to regulatory requirements, and should therefore be marked as alcohol (AL) in the system.

Target Service Level

Items are also segmented by different target service levels that reflect priority classifications of items. The three service levels are SL1 (99%), SL2 (98%), and SL3 (90%). The service levels are not decided based on a mathematical approach, but are estimated by the product's commercial value to the Company, exactly how this is performed is unclear. As mentioned in Section 3.4.5, it is a common practice for companies to set targeted service levels without any clear justification, which is not preferable to do according to (Chopra & Meindl 2016), see Section 3.4.5. A possible way to decide on the service level, according to Chopra & Meindl (2016), is by determining the cost of not having an item in stock as well as the cost of overstocking. However, according to the Project Leader interviewed, the cost of understocking incorporates more costs than just the sales loss such as loss of goodwill and damage of the brand name. The Company finds these costs too difficult to calculate and hence does not apply this way of deciding on the target service levels.

In M3 the Company usually sets a higher service level than the one intended to mitigate the risk of running out of stock. This is especially true for high-service level products where the 99% service level is normally set to 99.9%. The reason for this is mostly due to the increased pressure from end customers on product availability, which has also been highlighted in theory, see Section 3.3.2. A potential issue with this practice is that it can lead to excessive stock levels, thereby increasing the risk of inventory obsolescence. However, given that the Company primarily deals with items possessing a shelf life of a year or longer, the occurrence of expiring products is not seen as a significant concern.

Market Regulations

Since the Company distributes items on a global scale the products are also segmented by market-specific requirements. Before a new product is introduced and approved in M3, a team called Customs Control, will check if the product can be sold in all markets or if there are markets with regulatory requirements. This is then considered in M3 by filtering the inventory balance so that only approved items are visible at the DC serving a specific market.

4.3 Load Planner Overview

Load Planner is a system developed by the company to enhance the fill rate in the trucks between the CDC and the RDC. The trucks are mostly loaded with entire pallets of the same products for the DOs, thus it is important with stackability of the pallets. Load Planner considers which pallets can be stacked on each other by using the pallets' weights as well as how many kilos a specific pallet can have stacked on it. This helps to plan which goods can be sent together to fill the truck on either as much weight as possible, or as many pallets as possible. If there is a residue, in other words if a DO does not make up a FTL, the responsible Delivery Planner can choose to fill the truck with the next week's demand, or to not send the truck at all. Load Planner is compatible with M3.

4.4 Influential Variables

According to the Company there are three main variables that influence its inventory levels. The variables are *retailers' demand*, *safety stock*, and *demand forecast*.

4.4.1 Retailers' Demand

The Company's demand is obtained from the sales data which is reflected by the orders retailers put into E-shop. However, retailers can only order products that are in stock, hence the retailers' actual demand is not congruent with the orders they put in. Right now there is no way for the Company to know the retailers' actual demand for each product, thus the Company is compelled to rely on the order data in E-shop. The Company neither has any information regarding end customer demand data as it is not integrated with the retailer's information systems. This is, as already mentioned, a flaw according to theory, see Section 3.5.2.

According to the interviewees, the demand as seen in E-shop, varies between different items but is mostly constant over the year with seasonal variations. For the majority of products demand builds up towards Christmas and declines when the new year starts. The peak season is considered to be between July and Christmas. The demand variations is further investigated in Section 5.3 to verify the accuracy of the Company's own description.

4.4.2 The Company's Safety Stock

The safety stock at the Company is supposed to account for demand during the lead time required to procure new goods as well as demand and lead time fluctuations. The safety stock is calculated per item outside of M3 by Need Planners and the main factors considered when deciding the safety stock are a safety factor based on the service level, the standard deviation of the demand, lead time, the standard deviation of the supply lead time, and need per 5-day week. Comparing the factors to the theory, it can be stated that the Company considers both supply and demand uncertainty, which is what Chopra & Meindl (2016) suggests, but also the service level as Mattsson (2016*a*) suggests, see Section 3.2.4. Compared to Equation 3.6, the company considers more factors as Equation 3.6 only considers a safety factor and the lead time demand. It is possible to calculate suitable safety stocks in M3, but the Company does not consider M3's way of calculating sufficiently accurate and therefore calculates the safety stock itself.

In which echelon the safety stock is situated is dependent on what type of distribution flow is used. All items that is sent from the CDC in Helsingborg to an RDC, only have safety stock in the RDC. According to theory, see Section 3.3.2, keeping downstream safety stock is preferred for timely delivery speed, but not for the cost efficiency. Hence, the Company's safety stock strategy is beneficial for keeping a high availability. Theory also mentions that lead times should play an important role of where the safety stock should be situated. However, as the lead times from the suppliers to the CDC as well as the lead times from the RDC in Parma to the retailers is unknown to the master thesis students, nothing can be said about this.

Since lead times are an important factor in the calculations, it is notable that safety stocks in Europe do not need to be as high as safety stocks in other parts of the world, due to the significantly shorter lead times and consequently less variation in lead times. Additionally, an item with stable demand does not need as much safety stock as an item with variable demand. Furthermore, items with higher target service levels are assigned higher safety stock levels compared to those with lower targets. The safety stock levels are recalculated every week and entered manually into

M3. The Company's objective is to never let the inventory levels be under safety stock. This might be an indication that the inventory levels are too high since a safety stock is supposed to account for unforeseen events in the demand, see Chopra & Meindl (2016) in Section 3.1.2. The safety stock levels are therefore further examined in the quantitative analysis, see Section 5.7.2.

Lead Times in the Distribution Network

M3 holds information about the specific lead times between the different nodes in the distribution network. The lead time in M3 account for when an order is picked at the CDC in Helsingborg, until it is received at the RDC. The lead time thus incorporates handling and transportation. The transport lead time between CDC and RDC depends on where the RDC is situated as well as the chosen route. However, the lead time does not incorporate planning or delays due to stock outs at Helsingborg or other disruptions in the SC. The actual lead time is thus unknown, which should be recognized as a flaw..

In M3, the lead time is set as static, which means that it is always the same between the CDC and an RDC. This approach can present challenges as it does not account for unexpected events, stockouts, or other contextual factors that could extend the lead times. For instance, the container traffic can change depending on which company is driving, as, for example, some companies drive slower to save fuel. To mitigate this risk, SPOD regularly monitor the container traffic and changes the lead time if a deviating pattern is observed. It should however be noted that when calculating the safety stock, the Company do consider stochastic events as the standard deviation of the lead time is calculated for. This shows an inconsistency in how the Company considers lead times when controlling its inventory levels. Whether the lead times are actually constant between the different nodes are further investigated in the quantitative analysis, see Section 5.8.

4.4.3 Demand Forecast

The inventory levels are highly affected by the forecasting as a better forecast will lead to the possibility of holding lower inventory for better availability. However, the forecasting system utilized by the Company is complex and not fully optimized. Therefore, due to time constraints within this master's thesis, further investigation into how the forecasting is performed is not pursued. The performance and impacts of the forecasts are still under investigation, see Sections 5.6.2 and 6.2.1.

4.5 Shelf Life of Goods

Managing inventory of perishable goods presents unique challenges compared to non-perishable items, primarily due to the critical factor of limited shelf life that must be carefully accounted for. However, the Company has historically held items with long durability as the majority of their items have a shelf life of between six months and two years. Overall, the Company aim at not keeping items with a shelf life below 50 days. This strategy diminishes the shelf life as a critical factor since most theory suggests that products with shorter shelf life is more sensitive to the incorporation of shelf life in inventory management decisions, see Lusiantor et al. (2018)

and Ferguson & Ketzenberg (2006) in Section 3.5.2, and Yigit & Esnak (2023) in Section 3.2.4. However, it is still important for the Company to not neglect the perishability of the products when managing its inventory.

The Company uses the allocation method First-Expired-First-Out (FEFO), also called Earliest Due Date (EDD). However, if there are items soon to expire and the Company doubts its capacity to sell them within the designated time frame as projected by forecasts, it usually splits the products to the retailers through promotions or similar instead of risking obsoletes. Pushing goods to retailers can thus be an indication of keeping too high inventory levels and not managing the shelf life accurately. However, according to the interviewees, such splitting occurrences are infrequent and therefore not necessarily seen as a clear sign of excessive stock levels. This is verified in the quantitative analysis, see Section 5.12.

If a product expires, it is removed from the stock and marked as unavailable in M3. Subsequently, M3 makes a suggestion to replenish the stock with new products, provided there is still a demand. By forecasting withdrawals in the future, M3 can anticipate exceeding the expiration date in advance and make purchase proposals to ensure fresh products are in stock.

Need Planners are responsible for initiating the distribution of goods from the CDC to RDCs and retailers as soon as they detect a potential risk of obsoletes. M3 also creates a distribution plan for items that have a risk of expiring before they reach the end customer. A DO is created and sent to the Delivery Planner that in turn sends it to the RDC who will execute the distribution. The strategy of pushing products with short shelf life downstream in the SC is aimed at reducing the amount of obsoletes. However, this approach can lead to overstocking at downstream locations causing increased holding costs and decreased inventory turnover rate.

A limitation of M3 is that it does not account for the shelf life when orders are placed. For example, if an item expires in ten days but it takes 15 days to deliver it from the CDC to a particular RDC the system will still communicate that the specific item is available for order. Since the lead times within Europe are quite short, it rarely causes major problems. However, there is an ongoing project with the objective of implementing a shelf life control into M3. This helps the Company avoid sending goods that is outdated upon arrival. An ongoing implementation of GS1 will also help with full traceability since it makes it possible to see exactly when a batch is sent and where it is/has been. GS1 is a global standard to define a product through its whole SC. The product is provided with a GS1 barcode which for example includes location code of the factory and specific codes for the specific product. (GS1 n.d.) Through scanning this code, information about the product and its journey through the whole SC will be visible in M3. This is positive as according to theory, information sharing of shelf life, enhances the performance of the SC for perishable goods.

4.6 Managing Stock Outs

If a product is out of stock in any of the DCs, the consequences can be significant, particularly depending on the duration of the stock out. This scenario can result in an inability to meet retailers' demand for goods, leading to stock outs at the retailer level as well. According to the Acting Solution Owner, in a worst-case scenario, this can result in the product failing to regain momentum at the retailer, leading to decreased demand and necessitating adjustments or even removal from the forecast. The Need Planners are tasked with the responsibility of preventing stock outs to the best of their ability.

Even though Need Planners work to prevent stock outs, it still happens that items are out of stock. Stock outs are handled in M3 by both the Need Planners and Delivery Planners. In M3 the various DOs are assigned a status depending on the urgence of the order. Status A1 connotes that the order should have been sent earlier and that safety stock will be exceeded, hence the order should be released as soon as possible. However, it is important to note that while safety stock levels may be surpassed, it does not necessarily denote a stock out since there are still products available in inventory. Status A2, means that the order should be released if possible or postponed if necessary. When the order has status A1 the reason is usually that the items included in the order were not in stock when needed. If an order is A1 and there are no coveted items in stock, the order is ignored and placed on backorder, which also means that the lead time increases. Everyday the order is ignored, the MRP will recalculate the coveted amount and the A1 order will either be the same or increase due to new incoming orders from the RDCs. In some cases an order can be freezed by a Need Planner, which means that the goods get reserved to a specific RDC and is thus not incorporated in the MRP. Freezing orders is a approach described by Axsäter (2015) in Section 3.3.1. Reasons for freezing an order may include stock outs or delays from the supplier due to unforeseen circumstances, necessitating the rationing of goods to different RDCs. The base for rationing is the forecasting done by the Demand Planner.

4.7 The Company's Key Performance Measurement System

The Company uses many different KPIs as well as PIs. In this master thesis, only the KPIs and relevant PIs are presented. In the following sections, no calculations are presented.

4.7.1 Utilizing BSC for KPI Monitoring and Reporting

The Company presents its KPIs in a BSC that is updated monthly. The structure of it is based on three main business objectives: *Desire and can afford the Company offer*, *Reach and interact with the Company*, and *Create a positive impact together with the Company*. The majority of the time all KPIs are calculated and reported in different separate systems, such as Qlik Sense, PowerBI or tailor-made reports. All the required data is however collected from M3.

Desire and Can Afford the Company Offer

The Desire and Can Afford the Company Offer refers to the costs associated with the products that the Company sells. The Company has an ambition to measure supply cost development, which is the cost development of the whole product chain. Supply cost development is divided into three subcategories: *Purchase Agreement (PUA) Cost Development*, *Logistic Cost Development*, and *Quality Cost Development*. PUA Cost Development relates to the purchasing price and makes up the largest part of a product's total price when it has arrived to the DC. Logistic Cost Development refers to the distribution of products from supplier to DCs. Quality Cost Development concerns quality deficiencies in the SC. Currently, the department Need Planners belong to measures PUA Cost Development, while the department Delivery Planners belong to measures Logistic Cost Development. The Company follows up on Quality Cost Development but has not yet identified how they want to measure it.

The two subcategories PUA Cost Development and Logistic Cost Development are interdependent of each other and hence an optimization in one of them will not necessarily lead to an optimization for the Total Cost Development. The main optimization goal for the Logistic Cost Development KPI is to minimize logistical costs while maintaining or improving the efficiency and effectiveness of logistic operations. For PUA Cost Development the optimization goal is rather to minimize costs associated with purchasing of food items while ensuring efficient usage of these items, and maintaining their availability. According to the Business Navigator the Need Planner and Delivery Planner departments are not integrated and therefore the Total Cost Development can become suboptimal as each department tries to optimize its own KPI. The only coordination between them is through the Business Navigator, which is not working effectively due to lack of communication from both parties.

The Company hence has a problem with aligning the incentives between different functions, something that is of high importance to ensure effective inventory management. However, this problem is not uncommon in companies as theory shows that aligning incentives is a difficult task, see Norrman & Näslund (2019) in Section 3.5.1. The Company has an ambition to develop a platform where the two departments can coordinate their work and keep track of the total Supply Cost Development, but for now the project has been postponed. There is also an ambition to find an aggregated KPI that can measure both the PUA Cost Development and Logistic Cost Development, but there has been no success with it yet.

Logistic Cost Development

The Logistic Cost Development can be divided into four main second level KPIs: inbound, outbound, DC handling and space rental. Inbound refers to the transport between supplier and DC or between CDC and RDC while outbound refers to the transport from DC to retailer or from supplier directly to retailer. All of these units have a set of enablers (PIs) connected to them which are measurements that explain the development of the different units (KPIs). The enablers of interest for this master thesis are the following:

Inbound

- Inbound flow (m^3)
- PO fill rate (%)
- DO fill rate (%)

Outbound

- Outbound flow (m^3)
- Average volume / delivery (m^3) (Drop size)

DC product handling

- Full pallet share (%)
- Picking share (%)
- Cross-docking share (%)

Space rental

- Total stock volume (m^3)
- DC capacity utilization (%)
- Critical stock levels (TEUR) i.e. the value of products at risk of expiry before sent out to the DCs
- Turnover rate (/year)

Reach and Interact With the Company

The KPI Reach and Interact With the Company focuses on how well the Company presents itself to the customers and consists of *DC Availability* and *On Time Delivery* (OTD).

DC Availability Definition

The Company measures the achieved product availability at the RDCs. The items within each target service level, as detailed in Section 4.2.2, are counted daily to see whether the available balance is greater than zero, expressed as ”yes” or ”no”. A monthly availability is then calculated for each item at a RDC, which is aggregated to an availability for each target service level and eventually for the entire RDC. The availability is hence measured binary. If one item is out of stock one out of a hundred days, the item is considered to have a 99% service level. It is notable that this way of measuring the availability does not reflect the demand from retailers nor the demand from the end customer as the KPI only measures how many items are in stock and not how many items of the demanded ones are in stock.

OTD Definition

OTD is a KPI that assesses whether the correct quantity of a product is delivered to the initial receiving DC either on the expected day or up to 15 days prior. The Company is currently looking into a new way of measuring OTD once the implementation of GS1 is completed. The future OTD measurement will then use normal distributions of the lead times to illustrate the total accepted lead time of a certain product. The delivered product quantity will still be included in the measurement as it will register an incorrect quantity as a miss on the OTD.

Apart from the new way of measuring, the Company is also investigating if the OTD can be extended into three separate measurements: *OTD Sender*, *OTD Transport* and *OTD Receiver*. OTD Sender will look at if the supplier or the sending DC finished the product on time and shipped it when it was supposed to. OTD Transport will observe if the transporter responsible for the delivery was there to pick up the goods when expected and also delivered it when expected. Finally, OTD Receiver will measure if the DC received the product when they were supposed to.

Create a Positive Impact Together With the Company

In connection to the objective of creating a positive impact on people and planet the Company has an Absolute CO_2 emissions KPI. This KPI is seen as out of scope for this master thesis.

Chapter 5

Results & Analysis

The findings of the data analysis is presented in this chapter. It begins with a discussion of data quality in Section 2.8.2 and summarizes quantitative analysis in Section 5.2. Section 5.3 explores retailers' demand, while Sections 5.4.2 through 5.9 examine results related to the RDC in Parma, covering inventory levels, turnover rate, forecasting accuracy, safety stock levels, lead time, and DOs. Section 5.10 discusses inventory levels at the CDC and compares them to the RDC in Section 5.11. The effectiveness of shelf life management is assessed in Section 5.12, and product availability measurement is analyzed in Section 5.13. The chapter concludes with a summary of the second round of interviews in Section 5.14.

5.1 Ensuring Data Quality

The data quality is ensured by validating the measures' correctness, completeness, and consistency. The validation of the correctness is done through interviews. Through interviews it can be concluded that the data does not incorporate any specific events that should be considered, thus the data is seen as having a high correctness.

Table 5.1 shows the completeness of both the inventory data, and the sales/outflow data, revealing that some of the products have a quite low completeness. This incorporates both data for the CDC and the RDC in Parma. Products that do not have 100% completeness are either not active during this period of the year, or data is not registered. To make sure that there is no faulty data used, the weeks with blank data are discarded from calculations using the inventory data for that specific product. This means that for these products less data is used, which reduces the accuracy of their results.

The consistency of the data is high since all data is collected through M3 where the collection of data is automatic and therefore always done in the same way.

Table 5.1: Data completeness for products A-N.

Product	# of Blank Rows in Inventory Data	Completeness Inventory	# of Blank Rows in Sales/Outflow Data	Completeness Sales
A	0	100%	0	100%
B	0	100%	0	100%
C	1	99%	1	99%
D	1	99%	2	98%
E	34	67%	18	83%
F	1	99%	0	100%
G	2	98%	0	100%
H	17	84%	21	80%
I	1	99%	1	99%
J	13	88%	4	96%
K	26	75%	8	92%
L	5	95%	10	90%
M	2	98%	10	90%
N	28	73%	23	78%

In Table 5.2 the calculated weighted averages are presented. Each part of correctness, completeness, and consistency is weighted equally important, hence $\frac{1}{3}$. As the completeness is divided into data for the inventory and data for the sales/outflow, each part is weighted as $\frac{1}{6}$, which together makes $\frac{1}{3}$. Table 5.2 show that all products have a weighted average over 90% which is good.

Furthermore, as previously stated, retailers can only demand items currently in stock, which is the only accessible demand data. Consequently, actual demand data from end costumers is unavailable. Therefore, it is imperative to acknowledge that all quantitative analyses in the following sections are conducted using potentially misleading demand data, underscoring its significance in interpretation. However, products with high inventory levels allows the retailers to order the products they actually demand without limitations, thereby enhancing the accuracy of the data.

5.2 Summary of Quantitative Results

In Table 5.3, a summary of all the results from the quantitative analysis is presented. It is important to note that the classifications for the various results is arbitrarily chosen. The quantitative analyses are complemented by the qualitative ones to achieve a comprehensive understanding. All the various analyses are described in detail in subsequent sections in this chapter.

The scale for the AILs is "Good" if it is in between $\pm 10\%$ from the calculated benchmark, see Section 5.4, "High" if it is between $10 - 50\%$ over the benchmark, "Low" if it is less than -10%. Lastly, the grade "Very High" is when the inventory levels is more than 50% over the benchmark.

Table 5.2: Weighted average for products A-N.

Product	Correctness	Completeness Inventory	Completeness Sales	Consistency	Weighted Average
A	100%	100%	100%	100%	100.00%
B	100%	100%	100%	100%	100.00%
C	100%	99%	99%	100%	99.67%
D	100%	99%	98%	100%	99.50%
E	100%	67%	83%	100%	91.67%
F	100%	99%	100%	100%	99.83%
G	100%	98%	100%	100%	99.67%
H	100%	84%	80%	100%	94.00%
I	100%	99%	99%	100%	99.67%
J	100%	88%	96%	100%	97.33%
K	100%	75%	92%	100%	94.50%
L	100%	95%	90%	100%	97.50%
M	100%	98%	90%	100%	98.00%
N	100%	73%	78%	100%	91.83%

Regarding forecasts, if the average absolute difference between sold and forecasted quantities is six units or less, it is categorized as ”Good”. If it falls between six and 20 units, it is classified as ”High”. Lastly, if the difference exceeds 20 units, it is designated as ”Very High”.

For the safety stock, the gradation is outlined as follows: Products with a safety stock covering more than 15 days of forecasted demand are labeled ”Very High”; those covering between five and 15 days are labeled ”High”; for safety stocks covering four to five days of forecasted demand, the label is ”Good”; and if the safety stock falls below four days, it is categorized as ”Low”.

The terms ”Inconsistent” and ”Consistent” for the DOs is a description of what can be seen in the graphs, see Appendix A.7. Inconsistent describes an inconsistent pattern regarding reordering point and quantity, whereas consistent describes a more consistent pattern.

In terms of availability, the designation ”Good” indicates that the target service level has been met. Otherwise, if the target service level is not achieved, the designation is ”Low”.

5.3 Characterization of Retailer Demand

During the initial round of interviews, the term ”stable” emerged frequently among interviewees when characterizing the Company’s demand. This description is further explained in the second round of interviews as a consistency over time in regards of both the quantity and timing. A seasonal variation during the year for summer and winter products is also mentioned, as well as weather conditions affecting the end customer demand, which in turn affects the Company’s

Table 5.3: Summary of results for product A-N.

Product	AIL at Parma	Inventory Turnover Rate	Forecast Compared to Sales	SS	DO	AIL at HBG	Shelf Life	Availability
A	Very High	19.01	Good	High	Inconsistent	Very High	Good	Low
B	High	20.40	High	Very High	Inconsistent	Very High	Good	Low
C	High	13.35	Good	Very High	Consistent	High	Good	Good
D	Good	14.25	Good	Very High	Consistent	Good	Good	Low
E	Low	28.74	High	Low	Partly Consistent	Low	Good	Low
F	Low	10.14	Good	High	Inconsistent	Very High	Good	Low
G	Very High	18.50	High	High	Inconsistent	Very High	Good	Low
H	Very High	12.67	Good	High	Inconsistent	Very High	Good	Low
I	Good	11.37	Good	High	Consistent	Good	Good	Good
J	Good	17.94	Good	Very High	Inconsistent	High	Good	Low
K	Low	27.15	Good	Low	Inconsistent	Good	Good	Low
L	Good	49.47	Very High	High	Inconsistent	High	Good	Low
M	High	37.26	High	High	Inconsistent	High	Good	Low
N	High	28.07	Good	High	Inconsistent	Very High	Good	Low

demand. However, interviewees note distinct seasonalities and demand patterns across different countries. For instance, retailers serviced by the RDC in Parma experience increased end customer demand during warm weather, while those in Scandinavia witness increased demand during cold weather conditions.

To assess whether the demand varies a lot, the average demand for each product, along with its standard deviation, are calculated. To determine whether the standard deviation is high or sufficiently low, it is compared to a worst-case scenario. One of the distributions known for its wide scatter is the exponential distribution, characterized by a coefficient of variation (COV) equal to one. Hence, a rough measurement involves computing the COV for each product and checking if it exceeds one. If the COV surpasses one, the standard deviation must be deemed as high, since it has a scatter that exceeds one of the distributions that scatter the most. The COV for demand is obtained by dividing the average demand by the standard deviation of the demand. See Table 5.4 for a summary of the results.

Table 5.4: Average, standard deviation and COV of the retailer demand for product A-N.

Product	Average Demand	Standard Deviation	COV
A	74, 04	25, 61	0, 35
B	134, 33	45, 96	0, 34
C	14, 83	6, 41	0, 43
D	29, 31	14, 41	0, 49
E	67, 67	60, 80	0, 90
F	26, 85	20, 83	0, 78
G	135, 08	51, 92	0, 38
H	13, 25	5, 31	0, 40
I	6, 35	5, 39	0, 85
J	19, 13	13, 39	0, 70
K	37, 90	34, 49	0, 91
L	69, 67	22, 55	0, 32
M	57, 52	22, 02	0, 38
N	43, 21	17, 76	0, 41

From table 5.4 it can be seen that all the products have a COV below one, suggesting that their standard deviations are not considered high. Consequently, the demand for these products can be assessed as relatively stable. Among the five products with the highest COV, four of them are FD, which is reasonable given the variability in demand for these items.

Further, to gain an understanding of whether different products exhibit a distinct seasonal variation, the demand from the retailer for each product is plotted over the entire duration of its sales, see Appendix A.4. Among the FD products, E and F show some indications of seasonal variation. Product E, having been in the Company's range for a relatively short period, presents challenges in tracing variations. However, it appears that demand fluctuates, peaking from October to March and then dropping to zero. In contrast, demand for product F spikes during the summer months, from May to August. There are also hints of seasonal variation for the LT product H, with demand peaking around autumn, from August to October. For the remaining products, no distinct seasonal variation can be observed from the graphs.

Another interesting detection during the second round of interviews is that some of the Delivery Planners experience that retailers order more than they actually sell to create their own safety stock at the stores. This ordering behaviour do not consider the interdependence of other retailers. The Delivery Planners find this problematic as it leads to, what they believe, unnecessary stock outs in the SC, affecting other retailers.

5.4 Inventory Levels at the RDC in Parma

5.4.1 Benchmark Calculations

To be able to comment on the inventory levels at Parma, a benchmark has been estimated. This benchmark is inspired by an (R, Q) policy and assumes stochastic demand. The reorder point, R, is according to the Axsäter (2015), see Section 3.2.2, equal to the lead time demand, m, added together with the safety stock, SS, see Equation 5.1. The lead time demand is determined by utilizing the Company's data on sold quantities, wherein a daily average of sold quantities, S, is computed for each item and then multiplying it with the lead time L. The lead time is set to four days for all items as this is the transport lead time between the CDC in Helsingborg and the RDC in Parma. The safety stock calculations is described further down.

$$R = S \cdot L + SS = m + SS \tag{5.1}$$

The order quantity, Q, is estimated through an average of all the DOs sent during FY23 for each item. According to Axsäter (2015), the order quantity can be approximated by the EOQ formula, see Section 3.2.2. However, as the authors have no access to the ordering and holding costs of the items, it is not possible to calculate. The DOs are seen as a good alternative to the EOQ since the Company uses sophisticated tools to calculate how the products should be distributed to achieve economical benefits.

To account for demand fluctuations, a safety stock is estimated. The safety stock estimates are based on the S1 measure described in Section 3.2.4. As mentioned by Axsäter (2015), see Section 3.2.4 the S1 does not consider the order quantity, Q, which makes the estimate rather simplified compared to reality. Still, the S1 measure is seen as good enough to only give a benchmark when analyzing the inventory levels. The safety stock is hence calculated by multiplying the standard deviation of the lead time demand, $\sigma(L)$ with a safety factor that is set according to the item's target service level, see Equation 5.2.

$$SS = \sigma(L) \cdot k \tag{5.2}$$

The benchmark estimation for AILs is then calculated as Equation 5.3 suggests.

$$\text{Benchmark average IL} = R + Q/2 - m = Q/2 + SS \tag{5.3}$$

A flaw with the calculated benchmarks is that they cannot answer the question whether the Company has the correct inventory levels at the right time, but rather if the inventory is at a good level on average. It is therefore noted that the benchmark is more of an indication of whether the AILs are too high or too low.

Furthermore, it is noteworthy that the benchmark is based on sales data from the Company, and as the sales data is biased, the benchmark is also biased. Thus the only iNeed Plannerut the benchmark gives is how the Company is performing in relation to what the retailers can order. Therefore, the benchmark might be a bit low if compared to the actual demand.

5.4.2 Results of Inventory Levels at the RDC in Parma

For the results of the benchmark in relation to the inventory levels at the RDC in Parma see Table 5.5 and 5.6. The unit carton (CRT) is the unit all the data is registered in.

Table 5.5: Inventory levels at the RDC in Parma compared to the calculated benchmark FY23.

Product	AIL (CRT) during FY23	BenchmarkIL (CRT) during FY23	% diff. AIL-benchmarkIL
A	226	142	59%
B	341	246	39%
C	74	63	17%
D	103	100	3%
E	185	327	−43%
F	108	125	−14%
G	394	249	58%
H	51	27	89%
I	37	37	0%
J	72	73	−1%
K	99	160	−38%
L	92	86	6%
M	96	86	12%
N	110	74	48%

Table 5.6: Calculated averages from Table 5.5

Averages when AIL compared to benchmark.		
Average HT products	Average LT products	Average FD products
41%	28%	−24%
Average SL1 products	Average SL2 products	Average SL3 products
10%	22%	22%
Total average	-	-
17%	-	-

5.4.3 Analysis of Inventory Levels at the RDC in Parma

The results in Table 5.6 show that the inventory levels are predominantly too high compared to the benchmarks. On average the inventory levels are 17% too high. It can be seen that HT products are more prone to have excessive inventory as they are on average 41% over the benchmark. LT products also have high inventory levels, on average 28% over benchmark. It is however notable that product H has a much higher AIL compared to the other LT products, increasing the total average. FD products tend to have inventory levels beneath the benchmark with an average of −24%.

Looking at the different target service levels it is found that items with SL2 and SL3 have more excessive inventory, on average 22% over benchmark, compared to SL1, on average 10% over benchmark. The lower inventory levels for SL1 products is especially interesting, since maintaining products with a target service level of 99% typically necessitates a much higher stock level compared to a service level of 98% or 90%. Therefore the SL1 products should have a higher inventory level than the other service levels, still that is not the case. However, all service levels have excessive stock, hence it is rather that SL2 and SL3 products have too high inventory levels than SL1 having too low.

The results indicate that the Company is having a difficult time in maintaining adequate stock levels at the RDC in Parma, and especially in managing inventory levels to stay low enough. The Company particularly faces challenges with maintaining low inventory levels for HT products. For FD products it is the contrary, the Company struggles to keep high enough inventory levels. The reason to the lackluster inventory levels is further investigated in the second round of interviews and is found to be connected to various components of business infrastructure and the MEICS, which is elaborated on in the subsequent sections.

Looking at the graphs, see Appendix A.5, it is noted that many of the products experience periods of diminished availability on multiple occasions within the same time frame. The first simultaneous malperformance is at the end of FY23. In interviews it is explained that this could be a cause of the yearly clean up that takes place at each end of the FY, the interviewees are however not sure. The second simultaneous malperformance is between week seven and nine. It can also be seen in the graphs that after the dip in week seven to nine, there has been a drastic increase in inventory, indicating that there might have been a problem with supply for many products during this period. Non of the interviewees reckons that anything specific happend within this period, and therefore it is not further investigated.

5.5 Inventory Turnover Rates at the RDC in Parma

5.5.1 Results of the Inventory Turnover Rates at the RDC in Parma

The inventory turnover rate is calculated according to Rossi (2021), see Section 3.4.5, and thus the historical data on sold quantity has been divided with the AILs for each week during FY23. From this a yearly average inventory turnover rate of FY23 is calculated for each product and presented in Table 5.7. The yearly inventory turnover rate is calculated by multiplying the weekly inventory turnover rate with as many weeks as the data is available for that year. A yearly average based on each product type and target service level as well as a total average for all products is also calculated and presented in Table 5.8.

Table 5.7: Inventory turnover rates for product A-N.

Product	Inventory Turnover Rate per Year
A	19.01
B	20.40
C	13.35
D	14.25
E	28.74
F	10.14
G	18.50
H	12.67
I	11.37
J	17.94
K	27.15
L	49.47
M	37.26
N	28.07

Table 5.8: Calculated averages from Table 5.7

Average HT products	Average LT products	Average FD products
26.85	19.50	20.99
Average SL1 products	Average SL2 products	Average SL3 products
17.65	17.53	38.27
Total average	-	-
22.02	-	-

5.5.2 Analysis of the Inventory Turnover Rate at the RDC in Parma

The inventory turnover rate provides insight into the outflow from the RDC, as it indicates how quickly inventory is being utilized or consumed. The Company has a global targeted value of eight turnovers of the inventory per year. In Table 5.8, it can be seen that the average inventory turnover rate for the inventory in Parma is approximately 22 stocks per year. The inventory turnover rates at Parma is thus faster than the targeted turnover rate. Regarding the different product types, HT products have the highest inventory turnover rate followed by FD products and then LT products. This suggests that the LT products stay the longest in the RDC and HT products stay the shortest.

Looking at the different target service levels, it can be concluded that SL3 products have the highest inventory turnover rate and SL2 products have the lowest with SL1 product's turnover rate close by. From the round two interviews it is described that the service levels for the products are set globally based on the total sales as well as perceived commercial value the product brings to the end customers. However, different countries sell different amount of products to their end customers, making the service levels sometimes inaccurate to a specific market. This phenomenon together with the larger safety stock higher service levels should require, can be a reason to why SL1 and SL2 products are staying longer in stock compared SL3 products. Another possible reason for the different inventory turnover rates could be that the Company orders larger quantities for the slow movers, and therefore it takes a longer time to utilize the stock. This is further investigated in Section 5.9.

One of the interviewees stress the fact that for RDCs in markets further away, reaching a yearly inventory turnover rate of eight is much more difficult compared to the RDCs in the European market. According to the interviewee, it would be better to have different targeted goals for different markets. This is hence an explanation of why many of the inventory turnover rates are much higher compared to the targeted value. Additionally, it is relevant to question the feasibility of establishing a target inventory turnover rate, as it typically emerges as a direct outcome of the targeted service level. This issue is further discussed in Section 6.2.4.

5.6 Forecasting Accuracy at the RDC in Parma

5.6.1 Results of the Forecasting at the RDC in Parma

Comparison of the forecasted and actual sales quantities yields the graphs in Appendix A.6, and the values in Table 5.9 and Table 5.10.

5.6.2 Analysis of the Forecasts at the RDC in Parma

Observing the graphs in Appendix A.6, and the results in Table 5.9 together with the absolute averages in Table 5.10, for SL1 products, it can be stated that the forecasts are rather accurate. However, looking solely on the graphs it can be seen that the forecasts are not very reactive as the forecasting plot follows a quite constant pattern, while the sales plot is more fluctuating. Further, the graph for the FD product E shows that the sold quantities are not very aligned with the forecasted quantity. Despite that the average difference between the two quantitaties is only $-9,5$ CRTs. The reason for this might be that the quantities are zero for approximately the last five months of FY23.

SL2 products exhibit less precision in forecasts within each product type category compared to the SL1 products. The absolute average differences between forecasted and actual sold quantities are slightly higher, indicating a greater degree of variability and potential error in forecasting accuracy. The FD product K did not sell anything during the first three to four months and during the subsequent weeks the quantities vary a lot. Since the forecast is not very reactive, the forecast

Table 5.9: The difference between sold quantity and forecasted quantity for product A-N.

Product	Avg. diff. sold-forecasted quantity (CRT)
A	0.13
B	-9.25
C	-2.37
D	0.13
E	-9.5
F	-0.08
G	-11.94
H	-5.62
I	-5.65
J	-5.37
K	4.17
L	26.44
M	16.08
N	3.89

Table 5.10: Calculated absolute averages from Table 5.9

Average HT products (CRT)	Average LT products (CRT)	Average FD products (CRT)
11.95	5.62	4.78
Average SL1 products (CRT)	Average SL2 products (CRT)	Average SL3 products (CRT)
3.58	6.56	15.47
Total average	-	-
7.19	-	-

does not always follow these changes.

Forecasts for SL3 products generally undershoot actual sales, but demonstrate commendable adherence to sales trends, closely aligning with actual movements. A particular interesting observation is that the HT product L shows an underestimating forecast with an average difference of 26 units. No answers to why product L has such a poor forecast is found in subsequent interviews.

Especially interesting with product L, which is the only HT product with a significantly undershooting forecast, is that it is also the HT product with the lowest difference in percentage between inventory levels and the benchmark. This indicates a potential error in forecasting calculations but also in the subsequent management of the inventory. However, for all the other HT products the inventory levels are much higher compared to the benchmark but the forecasts are more accurate. This scenario strengthens a poor performance in the subsequent management of inventory.

Forecasting new products presents challenges due to the lack of historical demand data, as indicated by the interviewees. Among the 14 products studied, five are relatively new in relation to FY23. Of these, three exhibit an average absolute difference between sold and forecasted quantities classified as ”High” or ”Very High,” as shown in Table 5.3. Examination of the corresponding graphs in Appendix A.6 reveals that the forecasts struggle to align with actual sales. While this suggests that new products may indeed be more difficult to forecast, it cannot be definitively concluded as it does not apply uniformly to all new products.

Comparing the results in Table 5.10 with Table 5.6 in Section 5.4.2, no specific pattern can be seen. This means that there is no direct connection found between the forecasting and the inventory levels.

In the round two interviews, it is explained by the interviewees that when a forecast is not accurate to the reality, it is the Delivery Planners' job to hand this information to the Demand Planner that can change the forecast in M3. However, the Delivery Planners express that this process does not work seamlessly. The Delivery Planners also express discontent with how often the forecasts are reviewed, since a poor forecast makes the Delivery Planners' job more difficult.

5.7 Safety Stock Levels at the RDC

5.7.1 Results of the Safety Stock Levels at the RDC in Parma

As described in Section 4.4.2, according to the Company, its safety stocks at the RDCs should at least cover the lead time demand. Hence, the safety stock at the Parma RDC should encompass both demand and its fluctuations over a four-day period. Unfortunately, the absence of historical data on safety stocks prevents a detailed analysis of FY23. Instead, a satisfactory alternative analysis is done. This analysis involves assessing the coverage of the Company's existing safety stock in terms of days. This assessment incorporates forecasted future demand, inclusive of demand fluctuations, as outlined in Table 5.11. It is important to acknowledge that demand fluctuations represent the standard deviations of lead time demand, derived from historical data.

Table 5.11: Results from safety stock analysis.

Product	Current SS (CRT)	# days demand current SS covers	SS to cover four days demand (CRT)	Possible % decrease of SS
A	191	6.9	119	38%
B	581	17.72	142	76%
C	73	17.20	16	78%
D	202	17.10	40	80%
E	38	0.64	238	+526%
F	53	6.46	32	40%
G	131	11.84	45	66%
H	32	8.50	15	53%
I	22	8	11	50%
J	139	17.44	33	76%
K	61	3.32	74	+21%
L	153	8.23	75	51%
M	78	5.35	59	24%
N	76	6.59	45	41%

5.7.2 Analysis of the Safety Stock Levels at the RDC in Parma

An evident observation from Table 5.11 is the excessive safety stocks across the majority of the products, each covering more than four days of demand. The smallest potential reduction in safety stock, when comparing all items, is 24% for product M, while the largest is 80% for product D. In essence, there is room for reducing safety stock across almost all products. This may suggest that safety stocks were too large during FY23 as well, although definitive conclusions are constrained by data limitations.

Product E stand out from the others with an extremely low safety stock coverage in terms of days. However, this result can be misleading as it is only the first week of those included in the calculation that shows a forecast greater than zero; all subsequent weeks show a forecast of zero. Through interviews it has been confirmed that product E is about to be discontinued in the coming month which explains the low safety stock levels. However, during the months the product have been sold, the historical data shows a weekly average forecasted demand including the standard deviation of 355 units. In such a scenario, to sufficiently cover the lead time demand, the safety stock would need to be 284 units, an increase of 647% compared to the current safety stock. Therefore, it might indicate that the safety stock for this particular product was too low during FY23.

Product K also maintains a low safety stock coverage, specifically 3.32 days, which falls below the lead time of four days. However, in comparison to product E, the required increase in safety stock to cover lead time demand is relatively small.

Looking at only the amount in the current safety stocks it can be generally seen that HT products exceed both the LT and FD products. However, by observing how many days' demand the different safety stocks cover, excluding product E and K, it can be stated that all types of products within the same target service level have safety stocks that cover approximately the same amount of time.

When studying the inventory levels with the safety stock sizes in mind, some expected observations are found. Comparing only the LT products, the ones targeting a service level of 99% cover a lot more days of demand with the current safety stock than the ones targeting a 98% service level, and its safety stock in turn covers more days of demand than the ones targeting a 90% service level. This is expected as targeting a higher service level requires more safety stock (Chopra & Meindl 2016), see Section 3.1.2. However, the average difference between inventory level and the benchmark for these items shows no corresponding pattern.

From interviews it is explained that the safety stock calculations have been changed recently, implying that potential inaccuracies might arise from an incomplete calibration process.

5.8 Lead Time Precision

The lead time available in the Company's data is the transportation lead time from when a DO is sent from the CDC in Helsingborg to when it arrives at the RDC in Parma, which is the same lead time that is put into M3. This is thus not the actual lead time, as planning and postponement of DOs are not incorporated. Therefore only a limited data analysis is possible to make. By considering all the data of when a DO is sent and when it is received, it is possible to calculate an average and a standard deviation to see whether the set lead time of four days is accurate. In Table 5.12, it can be seen that the average lead time for an order being picked, shipped and received is approximately 3.95 days with a standard deviation of 1.22 days. This shows that the lead time set in M3 is quite accurate, but that there is a significant deviation from the average, thus the lead time deviation should be accounted for with safety stock. As described in Section 4.4.2, the Company considers supply lead time deviation in its safety stock calculations, which hence is positive.

Table 5.12: Lead time calculations.

Average actual lead time (days)	Std of actual lead time (days)
3.95	1.22

To get a more accurate picture of the lead time, subsequent interviews are further investigating planning time and postponement of DOs. The interviewees explains that all DCs have specific days where they plan and order to a DC. Different DCs are assigned different days to distribute the work load on the CDC in Helsingborg during the week. The RDC in Parma has its planning days on Wednesdays and Fridays. It then takes two days before the order is prepared and shipped, hence the lead time from putting an order to receiving it is actually six days. The interviewees also explain that since there are often stock outs at the CDC in Helsingborg, an intended order is many times postponed or split into smaller orders over a longer duration of time. This shows that the actual lead time is fluctuating a lot, making the lead time variation larger than the one calculated from the Company's data. When calculating for safety stock, the Company should hence account for these fluctuations and not only the lead time deviation sprung from the handling and transportation. Fortunately, as mentioned earlier, the Company's safety stock calculation already incorporates the supply lead time deviation.

5.9 DOs to the RDC in Parma

5.9.1 Results for DOs to the RDC in Parma

In Appendix A.7, graphs over product A-N's DOs are plotted together with the AILs at Parma. The average quantity of the DOs for the specific products are calculated and can be observed in Table 5.13. A summary of the results can be seen in Table 5.14

Table 5.13: Average DO quantities for product A-N.

Product	Avg. DO quantity (CRT)
A	70
B	107
C	72
D	80
E	149
F	77
G	115
H	15
I	33
J	46
K	66
L	68
M	71
N	67

5.9.2 Analysis of the DOs to the RDC in Parma

It can be observed in 5.14 that the HT products on average are distributed in larger quantities compared to both LT and FD products, which is reasonable as they are sold in larger quantities. One exception is the FD product E, which has the largest average DO quantity out of all the studied products, see 5.13. When comparing the different target service levels it can be observed that the SL1 products in general have DOs of larger quantities than the SL2 products. However, the

Table 5.14: Calculated averages from Table 5.13

Average HT products (CRT)	Average LT products (CRT)	Average FD products (CRT)
90	56	85
Average SL1 products (CRT)	Average SL2 products (CRT)	Average SL3 products (CRT)
93	55	69
Total average	-	-
74	-	-

SL3 products fall somewhere in between. That being said, the suggestion that the lower turnover rate of SL1 and SL2 products compared to SL3 products is attributed to high order quantities mentioned in Section 5.5.2 is only a possibility for SL1 products, since the ordering quantity is higher for this product type. However, a specific pattern between turnover rate and ordering quantity cannot be observed since SL3 products have the fastest turnover rate, but SL2 products the smallest ordering quantity.

When studying the graphs over the DOs from the CDC in Helsingborg and the RDC in Parma, see Appendix A.7, it can be concluded that most DOs do not follow a specific pattern regarding the order quantities and the reordering points. As mentioned in the theory chapter, see Section 6.2.2, Axsäter (2015) describes that an MRP for a MEICS usually updates the reorder points frequently, but should not change much over time. Regarding the order quantities, an MRP updates the quantities depending on the forecasted demand, hence the quantities can change. However, looking at the forecasts, see Appendix A.6, it is rather predictable and does not change much over time. Therefore it is questionable whether the fluctuations in the DOs are reasonable or not. It is noted that products with a more repetitive ordering pattern have a slightly better AIL when looking at Table 5.6. It is thus reasonable to believe that products with a repetitive pattern are more easy to handle, and products with a non repetitive ordering pattern are more difficult to handle. It should be noted that products with a lower AIL do not necessarily have a more repetitive order pattern, and thus there is no suggestion that products with an AIL close to the benchmark is easier to handle.

In the round two interviews, the reason for the high fluctuations in the DO quantities are discussed which gives some answers to the infrequent ordering pattern. One reason that all interviewees bring up is stock outs at the CDC in Helsingborg. Since the stock at the CDC supplies many RDCs, it is crucial to consider the interdependence between the RDCs and not let one RDC take all items in case of a shortage. According to the interviewees, there are often problems with shortages and stock-outs at the CDC, leading to an infrequent ordering pattern as DOs need to be sent later or in several splits over a longer duration of time. The interviewees attribute the occurrence of stock-outs to suppliers. Since the Company is not a major customer for many suppliers, it is often not given priority during periods of supply shortages. An interesting finding from the interviews is that the MRP system is, according to the interviewees, not considering the interdependence between the RDCs itself. Instead it is the Delivery Planners' job to go in and manually change the DOs to make sure that all the RDCs can be supplied to some extent. When changing the DOs, the Delivery Planners explain that they base their decision on a ”feeling” of how much they can order which is founded in experience. Some Delivery Planners follow the MRP’s suggestion directly, while other change the suggestions almost every time. The inconsistent way of working leads to disagreements between the Delivery Planners. This unstructured way of handling the interdependence of the RDCs is found to be a flaw that is further discussed in Section 6.2 and Section 7.2.

Another reason for the infrequent DOs are the Delivery Planners’ goal of maximizing fill rate in the trucks when sending goods. As mentioned in Section 4.3, the Delivery Planners have an IT system connected to M3 that helps them plan how to ship products to maximize the fill rate on either weight or the number of pallets. Many times the MRP suggests DOs that will not fill an entire truck, then the Delivery Planners need to manually add extra goods to the trucks to make sure the Company ship a FTL. The extra goods that are added is usually the next weeks demand, but sometimes the Delivery Planners add products with excess inventory at the CDC in Helsingborg. In other words, how the fill rate is maximized is different depending on which Delivery Planner is responsible. This makes the DOs less constant in both time and quantity.

Furthermore, the interviewees explain that they adjust the DOs when they encounter forecasts deemed insufficiently accurate. It can both be that the forecast is too low, or too high. When the Delivery Planners change the DOs, they do so on intuition of how much adjustment is required. The Delivery Planners stress that there are often differences between the forecast and the actual outflow, something they all derive to the forecast being reviewed too seldom. Another reason is also that the forecasts are not very reactive to fluctuations. This makes it important that Delivery Planners review and changes the DOs when needed. Given that the Delivery Planners heavily rely on forecasts to inform their work, the accuracy of the forecasts is paramount to their ability to perform effectively. Therefore an inaccurate forecast leads to a fluctuating order pattern.

One of the interviewees mentions that products facing demand variations are more difficult to forecast, which makes it more likely that the ordering pattern for these products are less infrequent. Comparing the ordering pattern with the variation of the retailers demand, a linkage between this cannot be seen. The products that present a more frequent ordering pattern are product C, D, and I. These products have a COV of the retailer demand between 0.43 and 0.85, see Table 5.4, which is significantly higher compared to the product with the lowest COV. Also, considering the graphs plotted in Appendix A.4, no one of the product is found to have a somewhat foreseeable seasonality. Looking further into the forecasting, see Table 5.3, it can be stated that the three products have a forecast marked as good, making it reasonable to believe that a fluctuating demand necessarily does not make it difficult to forecast the product, but only that a good forecast is paramount to facilitate the ordering of products. However, considering FD products it can be stated that they all have an infrequent ordering pattern, but also a high COV and for the most part a forecast marked as good. This contradicts the finding above, suggesting that the forecasting can be good, but at the same time lead to difficult handling in the ordering.

5.10 Inventory Levels at the CDC in Helsingborg

5.10.1 Results for the Inventory Levels at the CDC in Helsingborg

When investigating the demand at the CDC in Helsingborg, the AILs are plotted together with the outflow at the CDC. To estimate whether the inventory levels are too high or too low at the CDC in Helsingborg, a benchmark is calculated in the same way as for the RDC in Parma, see 5.4.1. Since the supplier lead times are unavailable to the master thesis students, an assumption of four days is utilized. This estimation is based on the shorter geographical distance between the suppliers in Scandinavia and the CDC, compared to that between the RDC in Parma and the CDC. Thus, it is assessed that the lead time should not exceed four days. However, to be cautious, it is chosen to not set the lead time below four days. The difference between the AIL for each product and the benchmark is presented in Table 5.15, and a summary can be found in Table 5.16. It should however be noted that the outflow plotted in the graphs in Appendix A.8 are only the DOs, POs or COs that have been delivered. There is, unfortunately, no possibility of extracting historical data on when DOs, POs or COs have been requested or frozen. Therefore the data does not give a completely accurate picture, but only an indication of how the CDC in Helsingborg is performing.

Table 5.15: AILs at the CDC in Helsingborg compared to the calculated benchmark FY23.

Product	AIL (CRT)	BenchmarkIL (CRT) during FY23	% diff. AIL-BenchmarkIL
A	3232	1470	120%
B	3446	2056	68%
C	1010	720	40%
D	721	709	2%
E	1151	2208	−48%
F	1627	768	112%
G	1005	600	68%
H	115	54	113%
I	256	246	4%
J	1080	862	25%
K	1203	1102	9%
L	215	149	44%
M	173	145	19%
N	247	131	89%

5.10.2 Analysis of the Inventory Levels at the CDC in Helsingborg

The results presented in Table 5.16, are summarized into averages of both the target service levels and the product types. On average, the inventory levels at the CDC are 47% over the benchmark compared to the RDC in Parma where the inventory levels are approximately 17% over the estimated benchmark. Looking into the different product groups it can be seen that all product groups are overstocked with HT products in the top with approximately 75% higher

Table 5.16: Calculated averages from Table 5.15

Average HT products	Average LT products	Average FD products
75%	45%	25%
Average SL1 products	Average SL2 products	Average SL3 products
49%	44%	51%
Total average	-	-
47%	-	-

inventory levels compared to the benchmark. Considering the target service levels instead, it can be seen that SL1 products have more excessive inventory levels compared to SL2 products. This indicates that the Company is also more anxious about keeping sufficient inventory for higher target service level products. This is again reasonable as higher targeted service levels should lead to higher inventories. However, this logic does not hold when examining SL3 products, which surprisingly have higher levels of excessive inventory compared to both SL1 and SL2 products. Additionally, it should be noted that product E brings down the average of the SL1 products as it is the only product that does not have an excessive stock, but instead a too low stock. Product E stands out as an outlier compared to other products, with consistently low inventory levels in both Helsingborg and Parma. Additionally, it's likely that the safety stock for Product E was insufficient during FY23. Hence, the product seems to be particularly difficult to handle.

5.11 Pattern Between AILs at the CDC and the RDC

5.11.1 Results of Pattern Between AILs at the CDC and the RDC

To examine potential patterns between AILs at the CDC in Helsingborg and the RDC in Parma, each product is assigned a gradation indicating its stock status compared to calculated benchmarks. If the difference exceeds 50%, it is labeled as "Very High"; if it falls between 10% and 50%, it is labeled as "High"; for differences between -10% and 10%, it is labeled as "Good"; and if it is below -10%, it is labeled as "Low". See Table 5.17 for the final comparison.

5.11.2 Analysis of the Pattern Between AILs at the CDC and the RDC

Comparing the CDC in Helsingborg with the RDC in Parma, see Table 5.17, it can be seen that no specific pattern is found. It can also be seen that the CDC has a tendency to have more excessive inventory than the RDC in Parma, something that might indicate that there is a bullwhip effect in the Company's MEICS. However, since the data accessible for both the CDC and the RDC is biased, finding a reliable correlation between the two DCs using data is not doable. Also, since the CDC in Helsingborg supports many other RDCs as well, the AILs at the CDC is dependent on many factors that are out of scope for this master thesis.

Through interviews it can be concluded that all Delivery Planners find that there are frequently too low inventory levels at the CDC in Helsingborg, making it difficult for the Delivery Planners

Table 5.17: Comparison of the AILs at the CDC and the RDC in Parma.

Product	AIL at Parma in relation to benchmark (CRT)	AIL at HBG in relation to to becnhmark (CRT)
A	Very High	Very High
B	High	Very High
C	High	High
D	Good	Good
E	Low	Low
F	Low	Very High
G	Very High	Very High
H	Very High	Very High
I	Good	Good
J	Good	High
K	Low	Good
L	Good	High
M	High	High
N	High	Very High

to order the quantities they need at the time they are needed. This is interesting as the calculations of the AIL compared to the benchmark indicates that the inventory levels at the CDC are predominately too high. However, the the calculations do not consider if the CDC has the right inventory levels at the right time, but only how the inventory levels are on an average. Therefore it might be possible that the inventory levels are too low when products are needed.

5.12 Shelf Life Consideration

5.12.1 Results for Shelf Life Consideration

All of the studied items have a shelf life of more than 360 days, see Table 5.18. To evaluate whether the Company's MEICS considers the products' shelf life in a good way, the number of times each product at the RDC in Parma is split between the retailers due to short shelf life during FY23 is counted. Also, the total waste of each product at Parma during FY23 is counted, see Table 5.18. The waste is different from the splits since it means that the product has been discarded from the RDC, which, apart from expiring products, could be due to damage of goods. However, even though the data on waste is not only due to expiring products, it is found important to consider.

5.12.2 Analysis of the Shelf Life Consideration

From Table 5.18 it can be observed that the MEICS has no problem considering the shelf life of the studied products. From subsequent interviews with Delivery Planners, it can be verified that they do not find shelf life to be a critical factor in their job, at least not in Europe. However, the

Table 5.18: The amount of CRT:s split and discarded during FY23

Product	Shelf life (days)	Amount split during FY23 (CRT)	Amount discarded during FY23 (CRT)
A	730	0	0
B	360	0	0
C	360	0	0
D	360	0	0
E	540	0	0
F	360	2	0
G	365	0	0
H	540	0	0
I	540	0	0
J	730	0	0
K	540	0	0
L	365	4	0
M	365	0	0
N	456	0	0

Delivery Planners mentions that when the lead times is longer, as it is when shipping to other continents, the shelf life is more of a critical factor.

It is important to note that since all the studied products have relatively long shelf lives, this might not accurately reflect how the Company handles items with shorter shelf lives. For products with shorter shelf life, the inventory control becomes more complicated as the shelf life affects the duration of time a product can stay in a DC. However, this is seen as a next step in analyzing the Company's MEICS and is thus out of scope for this master thesis.

5.13 Product Availability Measurement

5.13.1 Results for Product Availability Measurement

The achieved product availability for all studied items are aggregated for FY23, see Table 5.19. It is important to emphasize that the results stem directly from the Company's own measurements. Therefore, the product availability showcased in Table 5.19 indicates the number of days during FY23 that the products were in stock, not the number of weeks.

Furthermore, it is important to acknowledge that the results presented for product G represent an aggregate of all cluster versions of the product. Therefore it may not be fully representative of the individual product examined in this master thesis.

Table 5.19: Achieved availability for each product during FY23.

Product	Achieved product availability at Parma FY23
A	92.3%
B	87.0%
C	100.0%
D	93.5%
E	67.6%
F	90.3%
G	92.9%
H	91.8%
I	100%
J	76.9%
K	44.9%
L	76.2%
M	82.9%
N	81.8%

5.13.2 Analysis of the Product Availability Measurement

Out of 14 items, only two, product C and I, achieved its target service level, both LT items. Four products, specifically E, J, K, and L, have notably exhibited very low availability. It is worth noting that three out of these four products are FD items. This could potentially explain their poor performance, as FD products have, as the product type says, fluctuating demand. Additionally, all of these products have had periods where the sold quantity have been zero, further contributing to their availability issues. Also, looking at the AILs in Table 5.5, it can be stated that product E, and K have AILs quite far beneath the calculated benchmark. Product J has a negative percental difference between its AIL and the benchmark, but only with -1%. Product L does not have as fluctuating demand, but on the other hand a very underperforming forecast which could be a possible reason for the low availability. However, as earlier mentioned in Section 5.6.2 the average difference between the AIL and benchmark is positive and relatively low, suggesting that this may not entirely explain the issue.

In the second round interviews, all interviewees are asked about their thoughts on the Company's availability measure. A couple of the interviewees express that the Company's approach can present challenges since not all missing products at the RDC are necessarily requested by the retailers. For instance, retailers may already have a lot of stock of a particular product, making its availability at the RDC irrelevant. The interviewees find that a more effective approach would involve measuring product availability directly at the retailers. By doing so, the assessment would accurately reflect the actual demand and inventory needs of the end customers, leading to more precise planning and allocation of resources.

From the second round interviews it is also mentioned that the targeted service levels for all the products are set globally. This is found to be lackluster as different markets demand diverse products at various quantities. Therefore it can sometimes be difficult to reach the targeted service level, as an SL3 product can be highly demanded in some markets, even though it is not as prioritized by the Company.

5.14 Summary of the Second Round Interviews

In the second round of interviews, three Delivery Planners, one Delivery Planner manager, and a Development Manager are interviewed. The decision to primarily interview Delivery Planners stems from their responsibility for the DOs, which are the focus of this master thesis. Additionally, limited access to employees from other functions has constrained the possibility of interviewing individuals in roles such as Need Planners, Demand Planner and SPOD. An improvement to the study would involve interviewing a wider range of participants, including individuals from other functions, in order to be able to draw more substantiated conclusions.

The interviews focus on the Delivery Planners' work, as well as the company's maturity. Interesting findings from the interviews that are not linked to the quantitative analysis are presented in the following sections.

5.14.1 Organizational Set Up Problems in the Company

All interviewees raise concerns about the organizational setup of the Company. They find that there are too many functions involved in managing inventories, and it becomes clear that each role in the organization operates within a silo mindset, focusing on improving overall SC performance through their individual efforts. Additionally, there appears to be ambiguity regarding who is responsible for what in the inventory management process.

The interviewees describe that processes in the Company are assigned a process owner responsible for monitoring and improving them, which is positive from an organizational perspective. However, there are many processes involved in the larger process of inventory management, each with its own process owner. These process owners are not always coordinated with each other, which leads to SC discontent and suboptimal performance in inventory management.

5.14.2 Performance Measurement within the Company

The different departments within the Company are evaluated based on different KPIs, their perspectives on improvement vary accordingly. One notable example mentioned during the first round of interviews is the misalignment between PUA and Logistic Cost Development, two KPIs that may not always align in terms of optimizing Total Cost Development.

Another frequently highlighted example during the interviews is the disparity between KPIs assigned to Delivery Planners and Need Planners. While Delivery Planners are primarily assessed based on fill rate, Need Planners' performance is measured by availability. This misalignment can lead to inefficiencies, as it allows Need Planners to prioritize availability over truck fill rate when placing purchasing orders (PO) from suppliers, potentially missing opportunities to optimize transportation logistic. In essence, the challenge of aligning incentives in practice, as emphasized in Section 3.5.1 by Norrman & Näslund (2019), remains evident. Theoretically, see Simatupang & Sridharan (2005) in Section 3.5.1, excessive inventory levels and low product availability can be a consequence of misaligned incentives.

5.14.3 Information Sharing in the Company

It is evident that the company has a problem with sharing information effectively. The interviewed Delivery Planners express dissatisfaction with information sharing from internal SC partners, which affects the quality of their work. Given that the Delivery Planners fulfill an operational role downstream in the SC, their tasks are significantly influenced by the actions of upstream partners. For example, the forecasting done by Demand Planners impacts the DO proposals set by M3, which serve as the foundation of the Delivery Planners' work. If there are issues with forecasting, it is crucial that the Delivery Planners can communicate them with the Demand Planners. Additionally, Delivery Planners may be surprised by actions from other roles, such as Need Planners freezing orders without communication, creating disruptions in their jobs and hindering them from performing planned tasks.

According to the interviewees, one reason for poor information sharing is insufficient communication channels. Most communication occurs via email, leading to what one interviewee describes as 'email loops,' where communication goes back and forth several times without reaching a conclusion. Efforts to enhance communication and information sharing, both between functions within the company and with retailers, are ongoing, with joint meetings convened several times a month. Despite these efforts, certain information inconsistently reaches relevant parties. Therefore, while progress has been made in improving collaboration, there remains a need for more robust communication channels to ensure that pertinent information is effectively disseminated among all involved parties.

Regarding external information sharing, the Delivery Planners express communication problems with retailers as well as issues with collecting master data from suppliers. For example, information regarding promotions at retailers should be communicated several weeks in advance, which is not always followed. Additionally, the lack of insight into retailers' customer demand and inventory levels exacerbates inventory management within the company.

5.14.4 The Delivery Planners' Way of Working

Delivery Planners, responsible for managing DOs and maintaining inventory levels at the RDCs, have clear process descriptions in a quality management system called Canea. While all Delivery Planners are expected to follow the same procedures, the second round of interviews reveals common discrepancies in their approaches.

For instance, while some Delivery Planners strictly adhere to M3's proposals, others make adjustments to secure the supply or ensure adequate stock for other RDCs served by the CDC in

Helsingborg. Some rely solely on the forecast, while others use intuition and experience. Some prioritize truck fill rates without considering the fill rate at the receiving RDC, while others do not. In such instances, the effectiveness of the fill rate KPI may be called into question.

In summary, no two Delivery Planners work exactly alike, and each individual approach can affect the outcome of inventory levels. Therefore, the results for the studied products in this master thesis may be influenced by the specific approaches of the responsible Delivery Planner(s).

5.14.5 IT Requirements and Skills at the Company

From the interviews, it becomes clear that many employees find it challenging to utilize and understand the M3 system initially. Most of them share the experience of not having worked with an ERP system before, making it difficult for them to adapt. According to Lim et al. (2023), see Section 3.7.1, hiring employees with the right technical capabilities can be quite challenging, something that the Company seems to struggle with.

The Company employs various strategies to teach newly hired employees how the system works, tailored to different roles. Some employees undergo introduction courses, while others are paired with a buddy who guides them through system functionalities and workflows. However, the effectiveness of this training may vary depending on the individual buddy, resulting in a somewhat subjective introduction process. As a result, each employee's understanding and familiarity with the system may differ, providing varying conditions for comprehension and proficiency.

When system updates occur, they are reflected in the process description within Canea, and employees are typically notified via e-mail. For more significant updates, comprehensive step-by-step explanations are provided during meetings to ensure clarity and understanding for all team members. If something remains unclear, it is common for employees to reach out to colleagues for help. These knowledge maintenance practices are viewed positively from a theoretical perspective, as they can improve business performance. As emphasized by Chopra & Meindl (2016), see Section 3.7, organizational changes, and leadership commitment are equally important for success alongside the actual IT system.

5.14.6 Maturity at the Company

Evaluating an organization's SC and technological maturity would have necessitated a separate comprehensive study. Consequently, the assessment provided in this thesis is quite rudimentary, yet it still offers some insights into the level of maturity achieved. Ideally, interviewing more individuals within the Company would be beneficial, but limited access to interviewees posed a challenge in this regard.

SC Maturity at the Company

Following the second round of interviews, a preliminary assessment of the Company's SC Maturity is conducted based on the SCPM3 model, see Section 3.6.1. The Company has a lot of its processes documented in Canea which demands annual revisions of the processes. Each documented process is overseen by a designated process leader, process owner, and process team, who collaboratively strive for continuous development and enhancement. This structured approach to process management applies mainly to the Delivery Planners' department but is not extended to other crucial functions, such as Need Planners and Demand Planners. The disparity in process documentation across departments stems largely from their siloed working methods.

Based solely on the documented process descriptions and the existence of a strategic team with representatives from all functions, the Company's SC maturity level is assessed as Vision. However, to advance to a higher level of SC maturity, the Company must enhance integration across the entire SC. This entails improving collaboration and strategic alignment with suppliers and retailers while also focusing on internal integration. One crucial step towards improving the integration between all functions is the development of joint KPIs. These shared metrics will help the Company improve its processes, align its incentives, and synchronize decision-making, ultimately enhancing SC performance. Additionally, the Company should consider implementing a standardized approach to process documentation and improvement across all functional departments. This initiative will foster a more coherent and integrated SCM strategy, promoting efficiency and effectiveness throughout the organization.

The Company reveals that they have done a full SC maturity assessment following the Gartner Supply Chain Maturity Model. The Company is currently mapped at level two called "Anticipate". At Level two of Gartner's Supply Chain Maturity Model, organizations start to anticipate demand and SC needs while establishing basic planning processes. The next level is "Integration", where organizations integrate various functions and processes within the SC, focusing on improving efficiency and reducing costs through better coordination and synchronization. The full assessment made by the Company is in line with the findings from the second round interviews, strengthening the assessment of the Company being at the Vision level.

Technological Maturity at the Company

While a comprehensive evaluation is not conducted, a brief investigation based on the second round of interviews is performed to provide an indication of the Company's technological maturity level based on the model by Tiss & Orellano (2023), see Section 3.6.2.

On a scale of one to five, the Company's technological maturity is assessed at four. Within the technological dimension, the Company has well-functioning IT systems for data analysis and data exchange. However, challenges arise in gathering master data from suppliers, which encompasses crucial product information such as ingredients and volume. Similarly, data collection from retailers presents obstacles, limiting transparency in understanding their purchasing behavior compared to other local suppliers. In terms of process management, as discussed earlier, there are also areas that could benefit from improvement.

In terms of user experience, interviewees unanimously agree that current IT systems meet their needs and offer opportunities for user influence and development. Ergonomics also receives commendable feedback. However, regarding change management, a lack of unified practices across departments is evident. Varied strategies, including courses, learning from a buddy, and update announcements, are employed inconsistently.

Regarding organizational aspects, the Company aspires to become more digital and automate repetitive tasks. The primary hindrance to realizing these ambitions is not a scarcity of resources but rather a deficiency in change management practices. Regarding decision-making, all functions are represented in a council that conducts the discussions and makes minor decisions. However, significant decisions regarding new IT implementations and similar are elevated to a higher level due to their cost and complexity.

In summary, while the Company demonstrates a high level of technological maturity, achieving the next level necessitates the implementation of standardized processes across all functions. Additionally, establishing a unified and well-designed approach to IT change management is crucial, ensuring users possess the requisite competencies for successful adaptation.

Chapter 6

Discussion

The discussion derived from the quantitative and qualitative analyses are carefully structured following the framework established by de Vries (2005). Hence, Sections 6.1 through 6.4 delve into the physical context, inventory planning and control, superstructure, and the structure of positions.

6.1 Physical Context

6.1.1 Distributing Company

The nature of the Company, solely focused on distribution, presents challenges in certain scenarios. For instance, establishing a centralized policy, as mentioned by Axsäter (2015), see Section 3.3.1 can prove challenging due to the geographical dispersion of storage points, a characteristic that applies to the Company. However, according to Chaudhary et al. (2018), see Chapter 1, the MEICS with centralized decision and information sharing takes on great importance in the perishable goods industry. Therefore, it is good that the Company is aligning with this trend to remain competitive in the market.

6.1.2 Perishable Goods

When discussing the physical context of inventory management, it is imperative to consider the type of inventory, particularly perishable goods. Managing perishable goods requires the inclusion of factors such as shelf life and temperature zones in the ICS. In the studied products and the examined RDC in this master thesis, shelf life is not considered a critical factor. This is attributed to the extended durability of the products together with the short lead time within Europe, as confirmed in the second round of interviews as well as the quantitative analysis.

However, it is crucial for the Company not to entirely dismiss shelf life as an essential factor in its inventory management, as only a small fraction of all its products is examined in this case study. When handling products characterized by short shelf life, it becomes especially vital to incorporate the factor of perishability according to (Yigit & Esnak 2023), see Section 3.2.4. This ensures the maintenance of sufficient safety stock to prevent stockouts caused by expired products. Yet, maintaining high safety stock levels inevitably leads to increased product waste. In other words, it is a delicate equilibrium between preventing shortages and minimizing waste. Furthermore, accounting for shelf life facilitates cost management by minimizing wastage and associated costs.

Given that perishable products have the potential to undermine the service level (Yigit & Esnak 2023), see Section 3.2.5, it becomes crucial for the Company to assess whether any high-target service-level products have short shelf lives. However, the current method employed by the Company to measure service levels fails to integrate the aspect of perishability, potentially posing challenges in this regard.

In theory, see Section 6.1.2, the context of perishable products enhances the importance of information sharing but also introduces an additional layer of complexity regarding the process. This aspect is noteworthy to mention, especially considering the dissatisfaction with information sharing within the SC revealed during the second round of interviews. Although there may not be explicit complaints about sharing information regarding shelf life, it is crucial to recognize that other forms of information exchange do influence the lifespan of perishable goods within the distribution system. Nevertheless, initiatives aimed at implementing traceability through the GS1 standard offer hope for enhancing information sharing.

6.1.3 Included Lead Times

To the RDC in Parma, the transport lead time is relatively short, approximately four days, but with a significant deviation of 1.22 days from the average. Given this notable deviation, it is positive that the Company plans to expand its OTD measure to identify the reasons for the delays.

Orders are scheduled two days before preparation and shipping, effectively resulting in a six-day lead time. The actual lead time deviation is unknown but is surely more volatile as planned orders are frequently delayed due to shortages of goods at the CDC. It is crucial to account for the actual lead time and its variability when calculating safety stock. Fortunately, the Company's calculation method incorporates the standard deviation of the supply lead time, ensuring this consideration is addressed.

According to Muckstadt & Sapra (2010), see Section 3.2.3, shorter lead times typically necessitate lower inventory levels due to reduced uncertainty in demand during the lead time. Moreover, assuming constant lead times can lead to either waste or failure to meet target service levels (Transchel & Hansen 2019), see Section 3.2.3. Therefore, it is advantageous for the Company to consider both lead time and lead time deviation when calculating safety stock.

6.1.4 Retailer Demand Dynamics

The retailer demand is described by the Company as being foreseeable regarding when and how much the retailers order. This is confirmed in the quantitative analysis as the COV is found to be less than one for all the products. The Company also describes that there is a great tendency for seasonalities during a FY, however, this is not found in the quantitative analysis as only products E, F, and H show a sign of seasonality when plotting the sales over multiple years. Another interesting aspect of the demand pattern is the effect weather conditions are described to have on it, something that cannot be investigated with quantitative analysis as the Company does not save historical data on the weather.

The absence of end customer demand data complicates demand prediction, a concern frequently raised during second round interviews. Theory, see Barlas & Gunduz (2011), Lee et al. (1997), and Constantino et al. (2014) in Section 3.5.2, suggests that sharing such data helps mitigate the bullwhip effect, lower overall inventory levels, and enhance availability. A tendency for bullwhip effect is seen in the quantitative analysis when comparing the inventory at the CDC and the RDC in Parma. Also, as Delivery Planners experience that retailers sometimes over-order to establish their own safety stock, indicates that there might be a bullwhip effect starting already with the retailers. However, due to the absence of end customer data, a bullwhip effect from the retailers cannot be confirmed. In summary, the unavailability of end customer data is likely to contribute to the excessive inventory levels observed in the quantitative analysis.

6.1.5 The Company as a Customer

Insights from the second round of interviews reveal a prevalent issue of stockouts at the CDC. The primary cause of these stockouts appears to stem from shortages at the Company's suppliers, a circumstance often exacerbated by seasonal fluctuations in food products. It is declared that the Company, being a relatively small customer for many of its suppliers, does not always receive priority treatment, worsening the challenge of stockouts. Consequently, since Delivery Planners have the flexibility to manually adjust DOs, they sometimes order additional quantities to secure future orders after encountering a stockout. However, this practice of ordering extra stock can potentially result in inflated inventory levels, particularly if the specific product lacks high demand in a particular market. This could serve as another contributing factor to the observed excessive inventory levels of the studied products.

6.1.6 Inventory Placement

The structure of the Company's inventory system, which is a multi-echelon inventory system, imposes possibilities and challenges. As can be seen in the quantitative analysis there is a potential tendency for a bullwhip effect as the inventory levels at the CDC is more excessive compared to the inventory levels at the RDC in Parma. This is according to Lee et al. (1997), see Section 3.5.2 common to see in multi-echelon systems as more than one inventory level requires better information sharing to avoid distortion of demand information as it travels upstream in the SC, a facet in which the Company falls short.

The placement of safety stock is determined by the Company to be at the DC where the CO is initiated. Consequently, for pure DO products, such as the ones under study, safety stock is absent at the CDC and only present at the RDC. This practice diverges from the recommendations by Axsäter (2015), see Section 3.3.2, which advocate for allocating safety stock early in the material flow within a distribution system. However, decisions regarding the placement of safety stock involve a trade-off between cost considerations and customer priorities. Theoretical principles, see Chopra & Meindl (2016) in Section 3.3.2 suggest that having more downstream inventory prioritizes timely deliveries, a rationale that may resonate with the Company's circumstances, particularly given their handling of perishable goods and emphasis on product availability. Additionally, if the lead times between the supplier and the CDC are shorter in comparison to those between the CDC and the RDC, it is advisable to position the safety stock at the RDC. This ensures that stock remains closer to the customers, thus enabling better fulfillment of target service levels. Whether this scenario applies to the Company remains undisclosed, as the lead time from the supplier is not provided to the master thesis students. However, given that many suppliers are located in Scandinavia, it is highly probable that this is indeed the case.

6.1.7 Factors Influencing Safety Stock Levels

According to theory, decreasing safety stock without jeopardizing product availability entails either reducing supplier lead time or minimizing demand uncertainty. In the case of the Company, decreasing supplier lead time poses challenges, particularly because the Company typically holds a relatively small customer status and lacks the leverage to demand increased effort from suppliers. However, mitigating demand uncertainty can be attained by improving SC visibility and implementing more sophisticated forecasting methods. Nonetheless, the absence of end customer data poses a limitation in this regard, thus creating efforts to attain end customer data is of high importance.

6.1.8 Fill Rate in Trucks

The primary KPI that guides a Delivery Planner's actions is the fill rate in the trucks. While this metric is effective for optimizing transportation efficiency, it can inadvertently result in overstocking at the receiving RDCs. It is found to not be uncommon for Delivery Planners to prioritize filling trucks with available items at the CDC to improve the fill rate, even though the items are not needed at the RDC. In essence, this practice can contribute to the excessive inventory levels observed in the quantitative analysis.

6.2 Inventory Planning and Control

6.2.1 Forecasting Method

The forecasting analysis indicates flaws in the Company's forecasting methods, with the foremost being the need for more frequent review cycles. Reviewing forecasts more often than just a few times per year enables more agile responses to shifting demand patterns, resulting in more accurate DO proposals and optimized inventory levels. All forecasts are executed with equal computational effort; however, insights from second round interviews indicate that certain products may undergo more frequent reviews than others. This inconsistency can result in varying levels of accuracy among the analyzed products.

It is crucial to acknowledge that customer purchasing behavior cannot be predicted with 100% accuracy, leading to inevitable errors. The forecasts are designed to prioritize stability over reactivity, which is reasonable as the forecasts should follow long-term trends, however, this imposes limitations on the forecasts short-term accuracy. Additionally, the analysis in Section 5.6.2 shows that forecasting for new items may be challenging due to the lack of historical demand data, further complicating the accuracy of forecasts. Therefore, an improvement to the study would entail decreasing the inclusion of new products among those studied during FY23, to ensure a more accurate representation of the Company's forecasting accuracy.

Furthermore, it is important to highlight the inconsistency in subsequent inventory management practices. It is found that Delivery Planners utilize the forecasts to varying extents. Sometimes, they rely on intuition and experience rather than strictly adhering to the forecast. This variability in approach could contribute to the infrequent issuance of DOs and, consequently, excessive inventory levels.

Consequently, as no pattern is found between the inventory levels and the forecasting in the quantitative analysis, the flaws in the forecasting itself cannot be said to directly affect the inventory levels. It is rather factors within the business infrastructure that affects the subsequent management of the forecast, which in turn might affect the inventory levels.

6.2.2 MRP as Reordering Point System

The Company's ERP system with an MRP as its reordering point system meets the interviewees requirements. However, a significant flaw is discovered in the second round of interviews. As the MRP itself does not take into account the interdependence of the RDCs, the interdependence is handled manually by the Delivery Planners. This could be a functioning solution if the Delivery Planners handled the interdependence consistently, but since the Delivery Planners change the DO suggestions on intuition, the MEICS is not operated optimally. This could be a reason to why the Company's inventory levels are in general too high.

A solution to this problem could be to create a systematic way for Delivery Planners to change DOs when needed, such as using a priority list for more important markets or allocate portions of the Helsingborg inventory to each RDC. Another solution could be to make the system itself handle the interdependence on a central level, as today the system overlooks the fact that the Company operates as a MEICS.

Another problem with the MRP system is that in theory, it is mentioned by Axsäter (2015), see Section 3.3.1, that operating a centralized policy, which the Company does, requires a great deal of information to be shared for it to work efficiently. As the information sharing in the Company is poor, difficulties in the reorder point system are a fact. Especially the lack of end customer data aggravates the process. Accessing end customer data from the retailers would thus facilitate the inventory management for the Company.

6.2.3 Service Level Measurement

The Company's method of measuring service level is likened to Axsäter (2015), see Section 3.4.5, third definition, known as the ready rate. Opinions between employees in the Company are divided on whether this method is appropriate or not. Proponents argue that it provides a clear view of product availability in the DCs, while critics argue that it fails to accurately measure how well the Company meets its customers' needs, a flaw also identified in the theory by Muckstadt & Sapra (2010), see Section 3.4.5, of ready rate.

The issue expressed by the critics is enhanced by the fact that retailers can only order products that are currently in stock. Additionally, the current approach to measuring product availability relies solely on inventory levels at the final distributing DC, neglecting stock levels at the retailers themselves. This approach can pose challenges, as not all missing products at the RDC are necessarily requested by retailers. To enhance inventory management accuracy, it is crucial to measure product availability directly at retailers. This approach ensures assessments align closely with actual demand, enabling more precise resource allocation and planning.

Muckstadt & Sapra (2010), see Section 3.4.5 suggests that companies often establish product availability levels without clear motivation, and the Company is no exception. The target service level for a product is determined globally, but these predefined targets may not always align with customer demand across all markets. For example, a product designated with SL1 may experience slow turnover in a specific market where demand is low. As a result, the safety stock will be too high for the specific market and the products will remain longer in the DC, leading to inventory stagnation. This phenomenon could explain why the studied SL1 and SL2 products seem to stay longer at the RDC compared to the SL3 products.

An issue identified in the initial interviews is that the targeted service level entered into the system is often higher than the actual service level targeted for the product. As the quantitative analysis shows that the inventory levels are predominantly too high, this could be a possible contributing factor.

6.2.4 Inventory Turnover Rate Measurement

Another KPI determined at a global level is the inventory turnover rate. The quantitative analysis reveals that, overall, the products exhibit an inventory turnover rate that surpasses the desired goal of eight. One potential explanation for this discrepancy could be that the targeted goal is not aligned with the specific characteristics of the markets served by the RDC in Parma. Thus, having distinct targeted goals tailored to specific markets is preferable.

Moreover, it is relevant to consider whether an organization can simultaneously aim for both a target service level and a target inventory turnover rate. Pursuing a specific service level entails establishing parameters for reorder point (R) and order quantity (Q), which in most cases affect the inventory turnover rate as well. In essence, prioritizing a particular service level may restrict the organization's ability to directly impact the inventory turnover rate. The degree of interconnection between these two KPIs determines the ability to achieve both goals simultaneously. However, this depends on the type of service level measure the Company uses when calculating safety stock. When using the S1 measure, as done when calculating the theoretical benchmark, it is possible to have both a targeted service level and a targeted inventory turnover since they are mathematically not connected. However, considering that the Company employs a more intricate measurement, the choice to have a target inventory turnover rate at the same time as having a targeted service level is questionable.

6.3 Superstructure

6.3.1 Departments Involved

The Company is divided into multiple departments and roles, a structure that slows down its processes. Not only is it challenging to share relevant information among these departments, but it also takes longer time to synchronize and make decisions as a result. There also seem to be gray areas regarding responsibility and expectation of the different functions leading to discontent between the parties.

6.3.2 Aligning Objectives

The large number of departments involved requires aligned objectives, an aspect where the Company falls short. It is evident that there is a mismatch in KPIs between departments, both at a strategic level like the PUA and Logistic Cost Development, but also at an operational level like the fill rate and the product availability. This misalignment can according to Simatupang & Sridharan (2008), see Section 3.5.1, lead to excessive stock as well as stock outs, something that this case study exemplifies.

An interesting aspect is also that Ellinger et al. (2006), see Section 3.5.1, underscores how a misunderstanding of other departments' jobs can lead to mistrust and a lack of confidence in each other which exacerbates the alignment of incentives. Some of the Delivery Planners express uncertainty regarding responsibilities and a lack of full comprehension regarding the roles of other departments, thus this can partly be a reason for the Company's difficulty in aligning objectives. However, poor alignment is not uncommon to see as the Norrman & Näslund (2019), see Section 3.5.1, shows a high level of difficulty in translating aspirations for alignment into actionable practices.

6.3.3 Degree of Maturity

The low level of SC maturity in the Company further shows the difficulty the Company has regarding internal integration and working consistently throughout the entire organization. This situation significantly impacts the MEICS, as poor alignment, inadequate information sharing, and limited cross-functional collaboration exacerbate the difficulties of operating such a system.

The Company's high level of technological maturity indicates significant potential for enhancing SC maturity, given the presence of numerous integration tools. The fact that all functions operate the same system is a great foundation for becoming more internally integrated. However, the low SC maturity hinders the full potential of technological maturity due to the inconsistency between functions regarding processes and KPIs.

6.4 Structure of Positions

6.4.1 Sharing of Information within the SC

It is evident that information sharing, both internally and externally, is a critical area for improvement for the Company. Theoretical understanding, see Yuan & Qiong (2008) in Section 3.5.2, suggests that inadequate information sharing can contribute to the excessive inventory levels and poor product availability observed in the quantitative analysis.

Internally, challenges arise in sharing relevant information and incentives between departments and roles, complicating decision-making and inventory management. This complexity is largely attributed to the Company's complex organizational structure and inadequate communication channels.

When it comes to suppliers, the Company faces challenges in gathering relevant master data. However, from the retailers' perspective, several issues hinder effective communication. Firstly, the Company lacks access to actual end customer demand data, crucial for optimizing inventory levels and availability. Additionally, Delivery Planners may not always be informed about goods being pushed to retailers, leading to unexpectedly large orders. Market-specific activities like promotions, impacting order quantities, may also lack transparency to them.

6.4.2 Process Consistency

Process consistency, both between and within functions, is inadequate at the Company. Different functions work in different ways regarding process management, and places value on distinct priorities. For example, one function is careful with writing down processes whereas other functions find it excessive. This leads to discontent between the functions and creates an inconsistency within the organization that affects the inventory control process.

Moreover, within the Delivery Planner's department of the Company, there appear to be inadequacies in executing operational tasks. While Delivery Planners have clear process descriptions, more experienced individuals tend to develop their own working styles within the M3 system. Additionally, new Delivery Planners receive on-the-job training from a designated buddy, but as some Delivery Planners deviate from the prescribed processes, newcomers may learn different approaches. Whether this is problematic or not is difficult to say without having an insight into how the Delivery Planners job in M3 affects the more holistic perspective of inventory control. However, what can be said for sure is that it creates an inconsistency that can make it more difficult to manage the work of the Delivery Planners.

6.4.3 Requirements and Skills of an ERP System

The Company seems to struggles with employing personnel that possess the right knowledge to operate M3 effectively. What particular effect this has on the performance of the MEICS is difficult to answer without further empirical data collection, but it surely has a negative impact on inventory management.

Chapter 7

Conclusion

The final chapter provides a comprehensive summary of the study's findings. Section 7.1 and 7.2 provide definitive answers to the RQs posed, while the concluding Sections 7.3 and **??** *indicates next steps, contributions, and future RQs.*

7.1 Answer to RQ1

RQ1: *How does the MEICS perform in terms of managing inventory levels, product availability, and inventory turnover rate for product A–N?*

7.1.1 Inventory Levels at the Company

For the majority of products, inventory levels surpass calculated benchmarks at the RDC in Parma and the benchmark at the CDC in Helsingborg. The CDC has overall higher inventory levels compared to the RDC, which is a sign of the bullwhip effect, especially since the safety stock for the studied products are situated at the RDC in Parma.

Considering the different product types it is seen that HT products have more excessive stock than LT products, both in Helsingborg and in Parma, which might be connected to the larger order quantities sent in the DOs for HT products. This is however not sure, and it should be noted that LT products also have quite high excessive stock. FD products on the other hand is found to have on average too low inventory levels compared to the benchmark in Parma, but too high inventory levels compared to the benchmark in Helsingborg. In the quantitative analysis there is no clear sign of any reasons to the low inventory levels, but there might be a connection to the larger demand variation for FD products.

Regarding the different service levels, it is found that at the RDC in Parma SL2 products have more excessive stock compared to SL1 and SL3 products, which have the same excessive stock compared to the benchmarks. In Helsingborg on the other hand, SL1 products have the most excessive stock and SL3 products have the least excessive stock.

The overall too high inventory levels as well as the difference between the inventory levels at the CDC in Helsingborg and the RDC in Parma is not found to have a specific reason in the quantitative analysis. Instead it is believed that factors in the business infrastructure have an important effect on the outcome, which is concluded in Section 7.2.

Based on the rudimentary quantitative analysis conducted, it appears that many of the products examined have excessive safety stock levels. The Company has since a year back introduced modifications to the safety stock calculation method. Consequently, the Company is presently engaged in recalibration efforts, which may contribute the excessive safety stock levels. Additionally, it is conceivable that the responsible Delivery Planner aims to uphold elevated safety stock levels to prevent stockouts. Over time, these elevated safety stock levels may perpetuate the issue of excessive inventory levels for the studied products.

It is essential to consider the trade-offs between excessive stock and frequent stockouts. Excessive stock ties up capital and increases holding costs, while frequent stockouts result in missed sales and dissatisfied customers. Upon reviewing the Company's achieved product availability in Section 5.13, it appears that some products may require higher safety stock levels. However, it is important to remember the limitations of the Company's availability measurement method, as it does not consider actual demand. Therefore, based on the safety stock calculations presented in Section 5.7.1, there is potential for the Company to reduce safety stock for certain products without compromising availability in relation to the retailers demand.

7.1.2 Availability at the Company

The availability of the studied products is notably low, which is surprising given the high inventory levels maintained by the Company. However, the inventory levels shown in this master thesis are weekly averages whereas the availability is measured daily, making it possible that the inventory levels might go down to zero some days during the week, but the weekly average is still above zero.

Another crucial point to note regarding the Company's availability is that its measurement method does not account for retailer demand. Consequently, while availability might register as low, retailers could still be content because the product is not currently in high demand. Furthermore, since availability is assessed at the RDC, retailers may already possess sufficient stock to meet end customer needs, diminishing the significance of RDC availability.

Moreover, the global decision-making regarding target availability further affects the outcome of RQ1, possibly making the results less accurate for the markets served by the RDC in Parma.

7.1.3 Inventory Turnover Rate at the Company

Comparing the quantitative analysis with the Company's targeted goal, the inventory turnover rate at the RDC in Parma is high. However, as the targeted level of inventory turnover rate is set globally, it may not accurately reflect the conditions of the European market. Since the lead time is shorter and the market is larger in Europe compared to other markets, it is reasonable that the inventory turnover rate is higher than the global target. This is because products move quickly through the SC due to shorter lead times, and the larger market size results in higher demand for goods. Whether the inventory turnover rate is too low or too high is difficult to say without a reasonable benchmark.

7.2 Answer to RQ2

RQ2: *What role does the Company's organizational structure, performance measurement system, information sharing and synchronization, as well as IT systems play in the outcome of RQ1?*

7.2.1 Organizational Structure at the Company

The Company's organizational structure plays a pivotal role in the performance of the MEICS. With numerous functions involved in inventory management, maintaining a high level of information sharing and aligned objectives is imperative, yet this proves challenging for the Company. From both external and internal perspectives, the organizational structure is perceived as overly complex, hindering the effective operation of the MEICS. Externally, it is challenging to comprehend and map the organizational structure, a sentiment echoed internally, where employees struggle to discern responsibilities. This complexity contributes to SC discontent and difficulties with information sharing, affecting the Company's capacity to cooperate and efficiently maintain optimal inventory levels as well as effectively meet customer demand. Thus, the current organizational structure negatively affects the performance of the MEICS.

7.2.2 Performance Measurement System at the Company

The misalignment of objectives within the Company becomes evident through inconsistencies in KPIs between functions. This is a common challenge faced by many organizations, as bridging the gap between aspirations and actions proves to be difficult, see Norrman & Näslund (2019) in Section 3.5.1. The poor alignment of incentives negatively impacts the MEICS, exacerbating inefficiencies in inventory management. While all functions aim to optimize inventory management decisions, the divergence in how the different functions are measured results in varying perceptions of improvement, posing a significant challenge.

7.2.3 Information Sharing and Synchronization at the Company

It is evident that information sharing is lacking in the Company. Firstly, internal information exchange between the various functions involved in the MEICS is inadequate due to functional silos and poor communication channels. While efforts are made to enhance information sharing, the root of the problem appears to be the established silo mindset within the functions, which can be attributed to the complex organizational structure of the Company. This deficient information sharing results in flawed communication, hindering parties from efficiently performing their tasks and negatively impacting inventory levels.

Another aspect of information sharing that adversely affects the MEICS is the absence of end customer data. This presents a significant challenge as the Company relies on second-hand information from retailers, who can only order based on available stock rather than actual demand. There are indications that retailers tend to order more than necessary when products are in stock, thus distorting the Company's perception of demand. This phenomenon may contribute to the bullwhip effect observed in the Company's MEICS, as revealed by the quantitative analysis.

7.2.4 IT Systems at the Company

The ERP system utilized by the Company significantly influences the outcome of its MEICS, serving as the foundation of the reorder point system. While it is now commoNeed Plannerlace for many companies to employ ERP systems for inventory control, the system used by the Company falls short in handling the multi-echelon aspect of its inventory setup. When the system overlooks the interdependence of the RDCs, Delivery Planners need to manually adjust orders to ensure adequate supply to all RDCs. These adjustments are made based on the Delivery Planners' experience and intuition, lacking a mathematical rationale. Moreover, the variability in Delivery Planner training, ways of working and knowledge of the system further diminishes the efficiency of the Company's MEICS.

However, the high technological maturity the ERP brings to the Company is a positive aspect as it gives the Company prerequisites to become more internally integrated.

Another aspect related to the Company's ERP that could contribute to the excessively high inventory levels is the iNeed Plannerut of service levels for each product. Entering SL1 products with a 99.99% service level in the system, rather than the intended 99%, predisposes the Company to higher inventory levels.

7.3 Next Steps for the Company

To summarize what the Company needs to do next in order to enhance its performance regarding its MEICS, three key actions stand out.

Firstly, the Company should establish a systematic approach for Delivery Planners to manage their DOs while ensuring equitable supply to all RDCs. This involves clarifying Delivery Planner responsibilities preventing any single RDC from monopolizing CDC stock, thereby ensuring fair distribution among all RDCs. One potential solution is to create a priority list for RDCs, prioritizing those serving larger markets and allocating resources accordingly.

Secondly, the Company needs to focus on improving its information sharing practices. This involves breaking down functional silos and fostering a culture of open communication within the organization. Implementing robust communication channels and systems will facilitate the exchange of information among different departments. Exploring the possibility of leveraging M3 for communication, such as sending notifications, could for example be a valuable path to explore and develop further. Additionally, organizing cross-functional meetings and clarifying roles and responsibilities can be effective tools in promoting better communication and collaboration across the organization.

Thirdly, the Company should prioritize ensuring consistency in KPIs across functions to bridge the gap between aspirations and actions. Aligning incentives and objectives will facilitate cooperation and coordination among different departments involved in inventory management. However, aligning incentives can pose challenges, so it is essential for the Company to focus on enhancing mutual understanding between functions and clarify roles and responsibilities. Developing cross-functional process descriptions could serve as a viable solution to promote clarity and alignment across departments.

7.4 Contribution to Knowledge Development Within Theory and Practice

This master's thesis expands upon de Vries (2005) model and contributes with insight on how different aspects of business infrastructure influence the performance of MEICS. By bridging theoretical concepts with real-world applications, the study demonstrates how theoretical insights into MEICS are relevant in practical business contexts. This integration is vital for both academic understanding and practical implementation in SCM. In essence, the thesis enriches the existing literature by focusing on the intersection of MEICS and business infrastructure, offering theoretical and practical insights that can guide future research and operational improvements in SCM.

7.5 Future RQs

Due to time constraints, this master thesis has only studied parts of the Company's material flow to give an indication of how the MEICS performs and how business infrastructure affect the performance. It would thus be interesting to extend the research further on several aspects.

To begin with, expanding the study to include more products and additional DO flows between the CDC and other RDCs in Europe would enhance the quality of the findings. Focusing solely on Parma may introduce a bias towards this specific RDC, so broadening the scope would provide a more comprehensive understanding. Secondly, exploring other flows such as PO and CO flows to incorporate products with a shorter shelf life to see how it affects the MEICS when it is a more critical factor. Lastly, extending the study to markets beyond Europe would offer valuable insights on inventory levels and placement, especially considering the longer lead times involved. Longer lead times introduce new dimensions, including a higher risk of lead time deviations and greater significance of shelf life due to the extended duration products spend in the distribution system.

Furthermore, conducting a multiple-case study, in other words examining several case companies, would enhance the generalizability of the thesis findings. This could entail companies holding both perishable and non-perishable goods. Ultimately, this would enrich the scarce literature existing in the field and highlight the importance of studying the business infrastructure when evaluating the performance of an ICS.

Appendix A

Appendix

A.1 Interview Guide: Round 1

Name:
Title:
Department:
Date:

Company General

- Can you briefly describe the Company? Can we access a company description overview?
- Is it possible to access an organization tree?
- What is the business proposal for the retailers?
- What types of food do you supply and how do you categorize them?
- Who is responsible for the production and development of your food?
- What characterizes the food supply chain in general?
- What characterizes the demand for your business?
- Do you have large demand fluctuations between different geographical areas within Europe?

Network Structure

- Describe the structure of the distribution network in Europe.
- Can we access a distribution map?

- What distribution flows do you have, and how do you determine which flow to utilize?
- What are the number of echelons and nodes in the European system?
- What is the relationship between nodes? Relationship with retailers?
- What does the ownership structure look like?
  - Which nodes can be controlled and which are externally owned/controlled?
- What information systems are you using today?
  - Are there challenges with information sharing?
  - Do you have a VMI (Vendor Managed Inventory) system?
  - Do you have an ERP system?
- How are distribution activities such as transportation and warehousing solved?
  - Is it managed by a 3PL or internally?
  - Do you use a WMS?
- Do you see any challenges within your current distribution network?

Inventory Control System

- What are the main steps in your inventory control process and who is responsible for the different steps?
- Is it managed in the same way at all warehouses? Ergo, is it centralized or decentralized?
- How do you handle lead times between the different nodes in the inventory control system?
- How do you segment your products within the system?
- What is your ordering policy?
- What is your review policy? (Continous vs periodic)
- Do you have any restrictions on order quantity (Q)?
- How often do you update your policies?
- Are there any restrictions regarding this?
- What data do you base the policy parameters on? Historical? POS? More complicated?
- What is your lead time demand distribution?

- How do you calculate your inventory position?
- How do you handle backorders?
  - Lost sales?
  - Service constraints?
- How do you decide on safety stock?
- How do you forecast demand/how much you should have in stock?
- How do you calculate forecasting errors?
- What IT system are you using for inventory control?
- How is it operationalized?
- What are the limitations and the capacity of this IT system?
  - Are there challenges with information sharing?
- What are the main challenges in general with the inventory control system?

Product Specifications

- What types of products are handled and what are their characteristics?
- Requirements for special facilities? (e.g. cooling, humidity)
- How does this affect inventory control?
  - Segmentation?
- How is limited shelf life taken into consideration?
- How is food waste managed?
- Are there any requirements and regulations to comply with? For example regarding environment and health.

Performance Measures

- What KPIs are you measuring regarding inventory management?
- How do you define them?
- How do you measure them?
- What are your targeted goals? (e.g. inventory levels)

- How are you performing?

Available Data

- Do you have demand data over time?
- On which level do you store the demand data?
- On which time interval do you gather and store demand data?
- Do you have data on inventory levels over time?
- Do you have data on lead times between the different nodes?
- Do you have access to KPI performance over time?
- Can we access data on shelf life for the different products easily?
- Do you have historical data on the inventory turnover rate?
- Do you have historical data on the inventory turnover rate?
- Do you have access to historical demand plans?

A.2 Interview Guide: Round 2 - Delivery Planners

Name:
Title:
Department:
Date:

General About Delivery Planners

- How long have you had this position? What have you done at the Company before?
- Do you have any specific schedule for planning of DOs?
- How far in advance should orders be placed to ensure delivery at the desired time?
- Do you follow the process description written down in Canea when you work?
- Do you work towards any specific KPIs?
  - Do you find them helpful?
  - Do you think any other KPI would be helpful?
  - How do these KPIs affect the company's total performance?

- What are your thoughts and opinions on the way you currently measure availability?

Collaboration

- Which other roles are your daily work affected by?
- Which other roles and decisions do you influence in your daily work?
- Do you find that these roles strive towards the same goal/objective as you do?
  - Do you believe that the organization in total strives towards the same goals?
- When you plan and make larger decisions, do you synchronize them with other functions, such as need planners for example?

IT Systems

- Do you find it easy to work within the IT systems required for your work (especially M3)?
- Do you believe that you got a good introduction to the IT systems when you started working?
- Are you continuously updated about the IT systems?

Inventory Levels

- In A.5 you can see that high-turnover products have more excessive inventory levels than low-turnover products. Why do you think that is? Are high-turnover products harder to handle?
- In A.5 you can see that the inventory levels for most of the products are quite low at the end of FY23. Do you know if there is a reason for this?
- In A.5 you can see that between weeks 7-9 (end of October 2022) the inventory levels have decreased for many of the products. Do you know if there is a reason for this?
- The higher the target service level, the longer the product stays in the RDC (low turnover rate). Is this correct and in that case why is this the chosen approach?

DOs

- In A.7 it can be seen that the DOs are infrequent in both quantities and reorder points. Do you have any explanations for why this is?
  - Some of the DOs are very repetitive - what is the difference between these products compared to the others?
- On average the DO quantities are larger for high turnover products compared to low turnover products, and also for SL1 products compared to SL2 products. Is there a reasoning behind this?

- Do you have a lot of problems with too low inventory levels at Helsingborg?
  - How often do Need Planners need to freeze orders in M3 due to stock outs in Helsingborg?
- Do you often change M3s DO proposals manually?
  - What can be the reasons for these changes?
- Do you think that you have enough information to make accurate decisions regarding DOs?
- Do you find it easy to share important information with other connecting roles?
- Is shelf life a critical factor you often need to consider in your work?

Safety Stock

- What are your responsibilities regarding safety stock?
- Product E has a quite low safety stock. Why do you think that is?
  - After week 13 2024 the forecasts show zero for the subsequent weeks for this particular product. What is the explanation for this? Is it going to be taken out of stock or has the forecast not been updated yet?
- All the other products have quite excessive safety stocks. What can be possible reasons for this?

Forecasts

- What are your responsibilities regarding forecasts?
- How well do you think the forecasts are generally followed?
  - Do you ever deviate from the forecast when placing DOs?
- Do you consider that the forecast should be more reactive?
- What could be possible causes of errors in the forecasts?
  - In A.6 you can observe that the forecast for SL90, product L, shows an underestimated forecast with an average difference of 26 units. Why do you think that is?
  - In A.6 you can observe that the forecast for the SL90 items generally undershoot actual sales. Why do you think that is?
- Are the forecasts done with the same computational effort for all products?
  - For example, in A.6 you can see that the forecasts for low-turnover products are a bit more aligned with the sold quantities compared to high-turnover products. What are the reasons for this?
- How would you describe the demand from the retailers? Motivate!

A.3 Interview Guide: Round 2 - Development Manager

Name:
Title:
Department:
Date:

Supply Chain Maturity

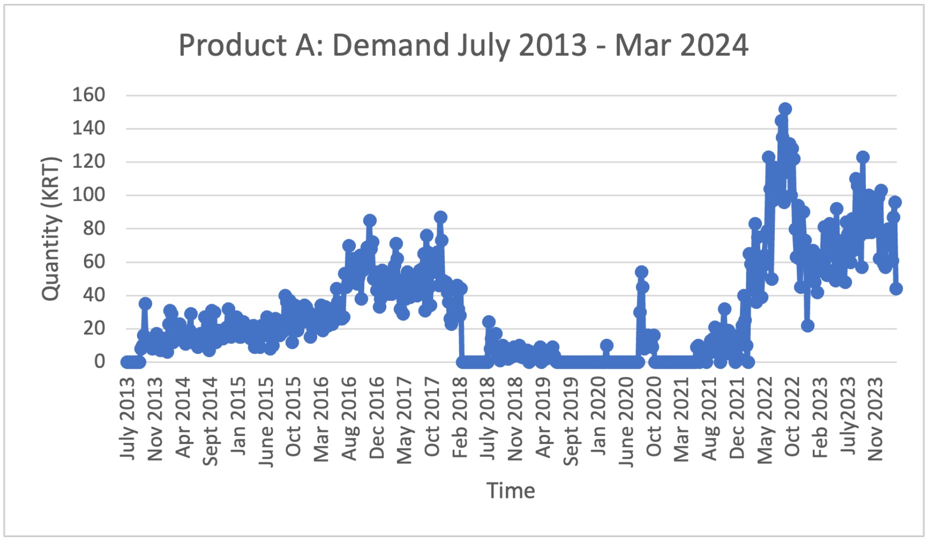
- We know that you have written down your processes in, for example, Canea. Do you think that the processes regarding inventory management are standardized and followed?
- Do you measure how good your processes are and develop them accordingly?
- Do you test your processes before implementing/updating them?
- Do you have process owners?
- Do you document your operational strategies and note changes?
- Do you believe you are working together within the organization to improve overall supply chain performance? If so, elaborate on how you do it.
- Do you have any cooperation between marketing, purchasing and operations?
- Do you have a strategic planning team?
  - Does it consist of people from several departments?
- Do you cooperate with your suppliers?
- Do you consider your supply chain to be integrated with customers and suppliers?
- Is your supply chain flexible? In other words, can it handle different types of disturbances and adapt easily accordingly?
- Do you carry out forecasts for individual retailers?
- Do you share information about your demand and stock levels with your suppliers?
- Do you monitor your process flows with specific KPIs that you analyze in special programs?
- Are your KPIs helping to improve your processes?

Technological Maturity

- Technologically

- What analysis methods do you use?
  - What kind of analyzes do you do?
  - What is the objective of the analyses?
  - Is the right data collected at the right time?
  - Is data collected automatically or manually?
  - How often is data collected?
  - Do you have reliable sources for data collection?
  - How well does the IT system share data with different departments and external actors in the supply chain?
  - How well do you update and measure your processes?
- User experience
  - Do the IT systems meet your needs?
  - How well are the users' wishes integrated into the development of the IT systems?
  - How do you work to facilitate the integration and use of new technologies?
  - How many different IT systems do users need to be able to handle?
- Organizationally
  - How standardized and structured are your processes?
  - What is your strategy to ensure that all users have the right skills to be able to use the various IT systems?
  - Who is involved in decisions about whether to implement new technologies and who makes the final decision?
  - How do you view technology within the Company and what progress do you want to make in the area?
  - Do you have the resources to make these desirable changes?

A.4 Graphs of Retailer Demand Over the Duration of the Products' Sales



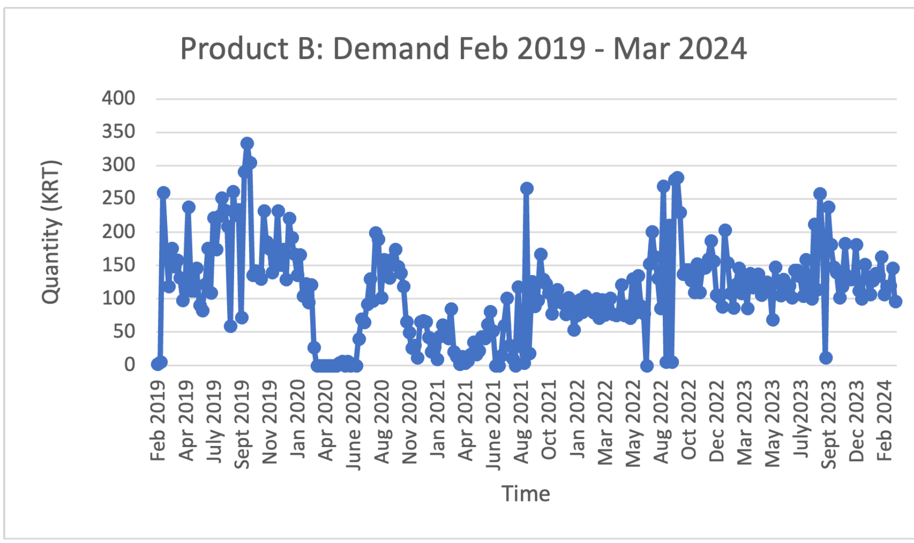
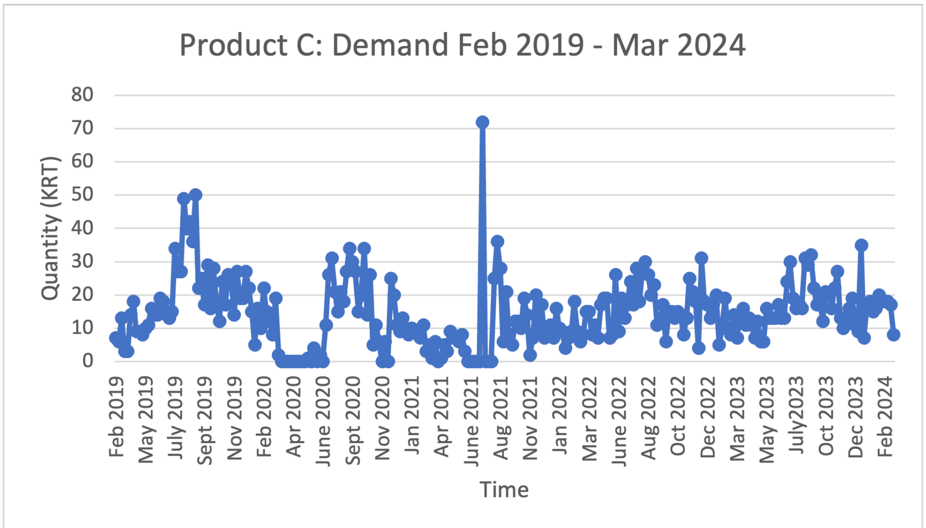


Figure A.1: Graphs of demand over the duration of its sales SL1 HT products.



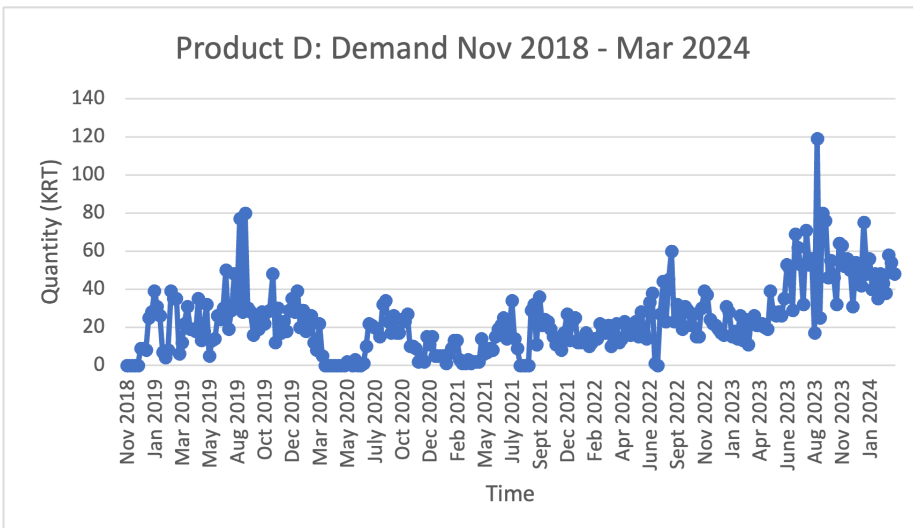
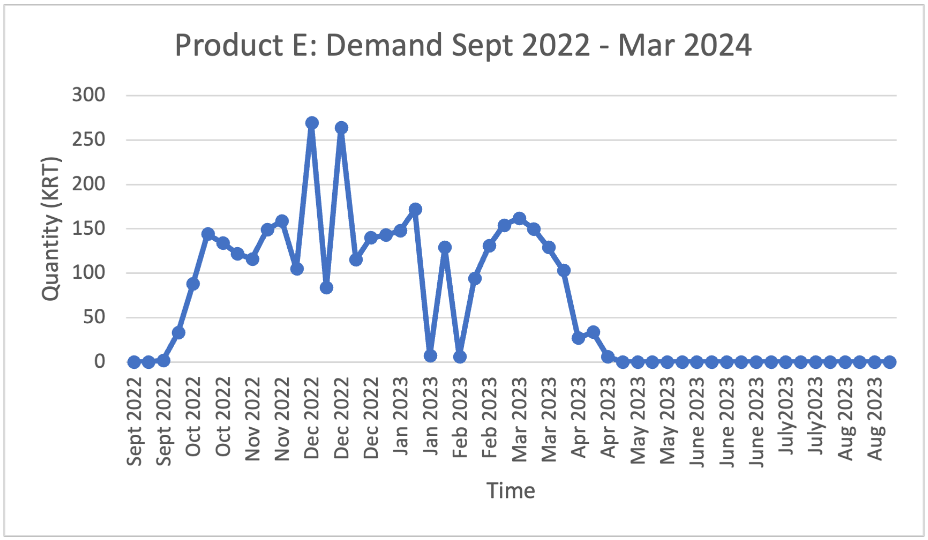


Figure A.2: Graphs of demand over the duration of its sales SL1 LT products.



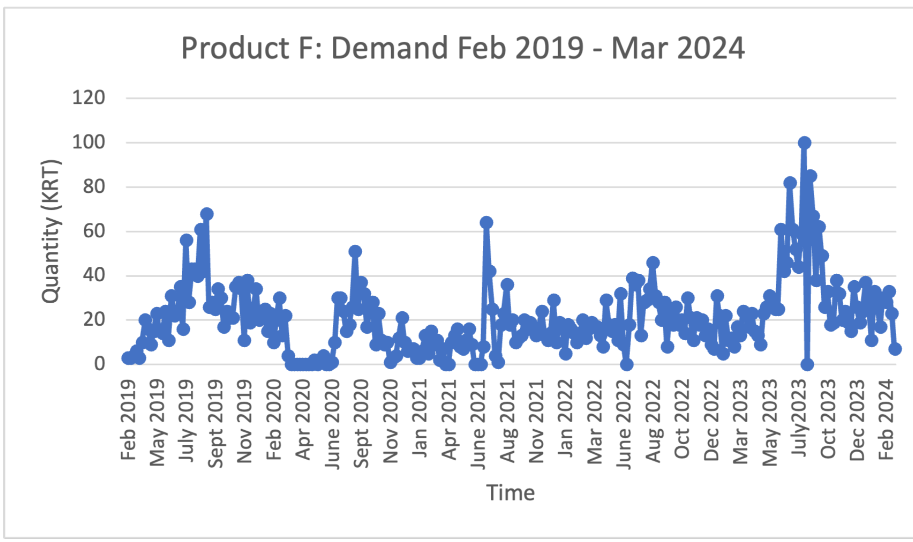


Figure A.3: Graphs of demand over the duration of its sales SL1 FD products.

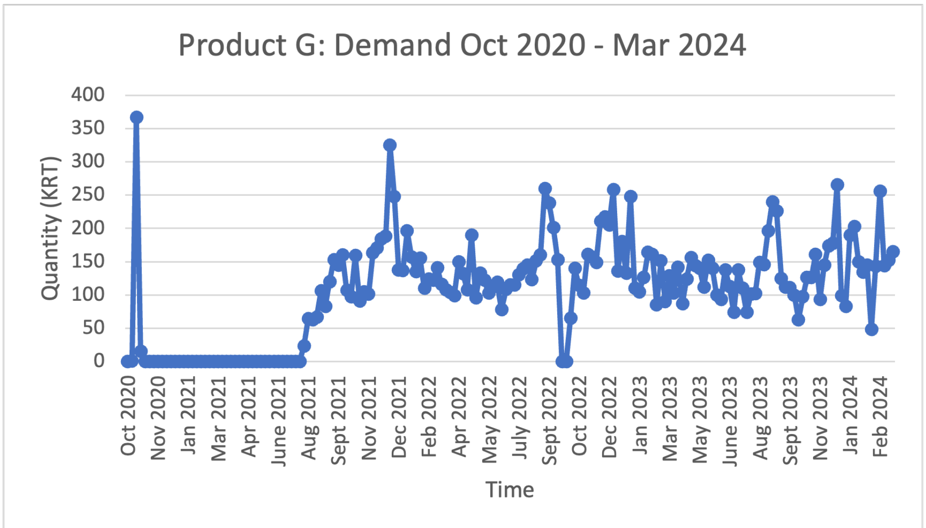
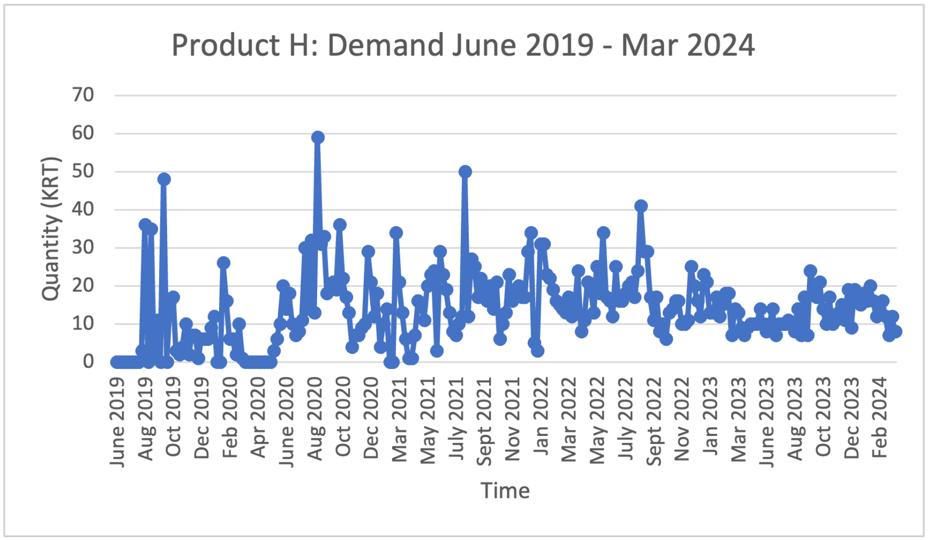


Figure A.4: Graph of demand over the duration of its sales SL2 HT product.



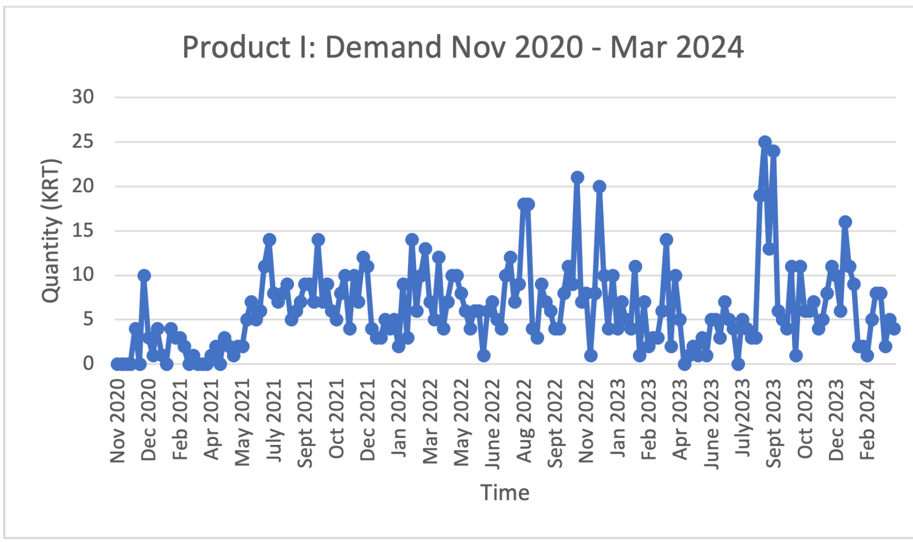
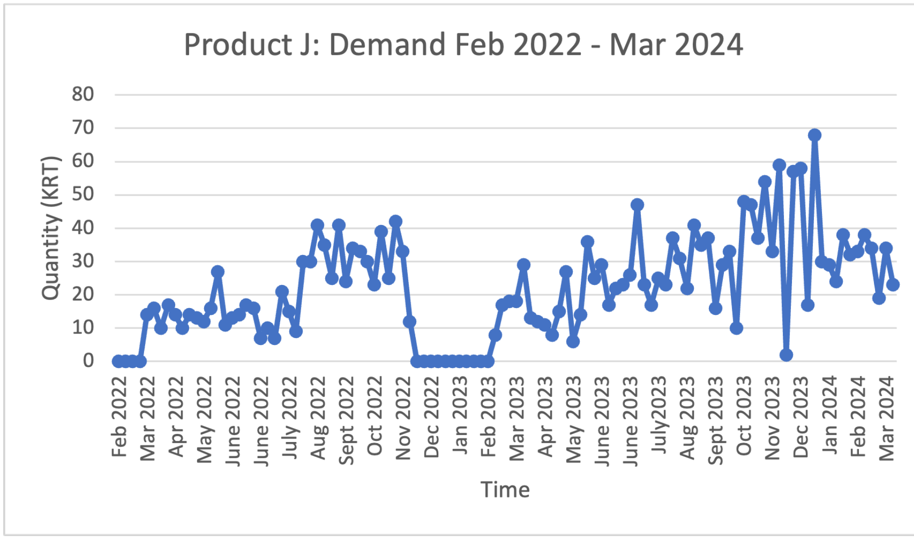


Figure A.5: Graphs of demand over the duration of its sales SL2 LT products.



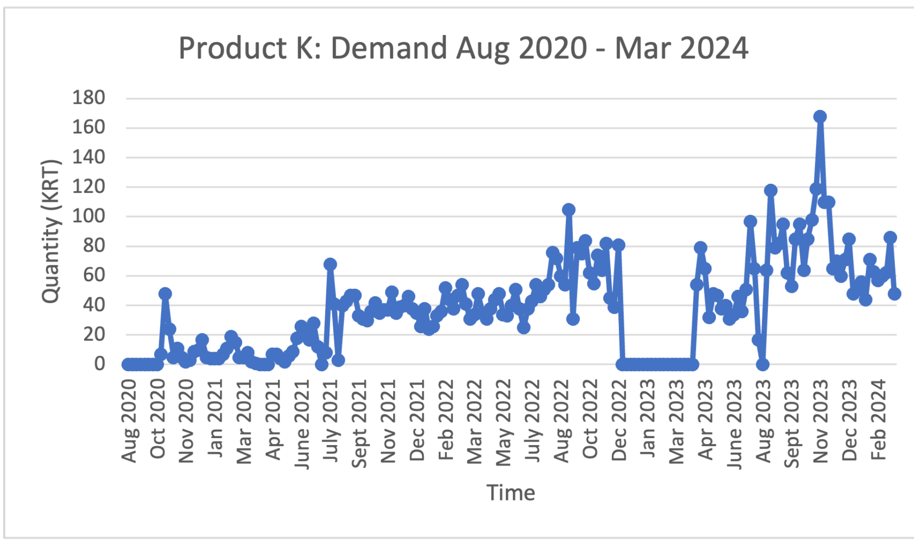


Figure A.6: Graphs of demand over the duration of its sales SL2 FD products.

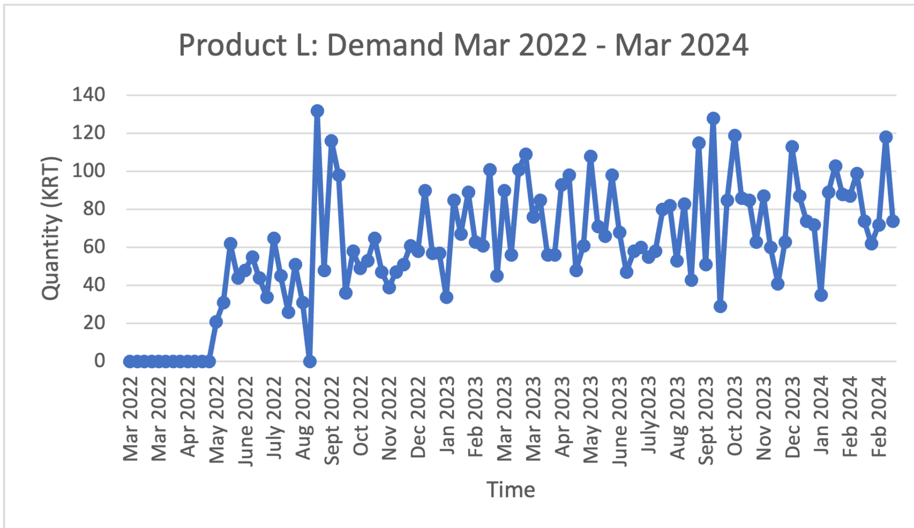
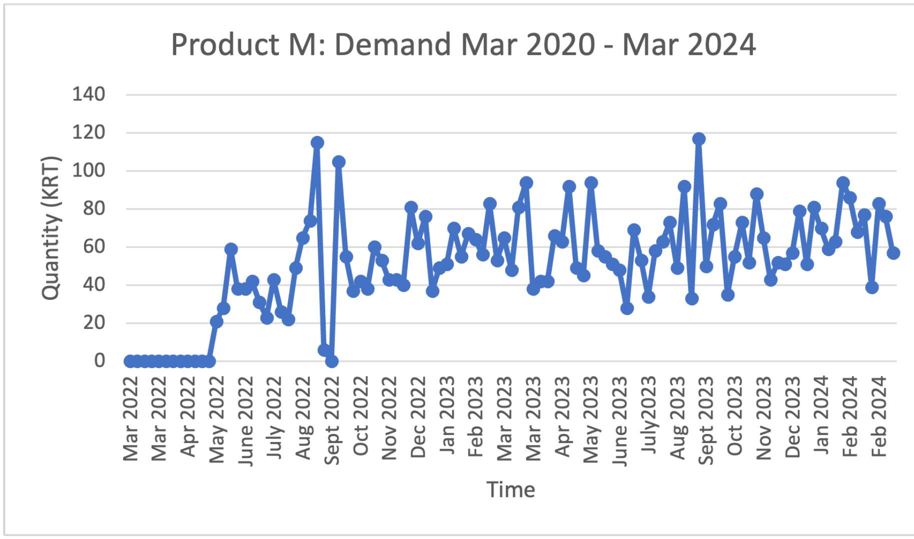


Figure A.7: Graph of demand over the duration of its sales SL3 HT product.



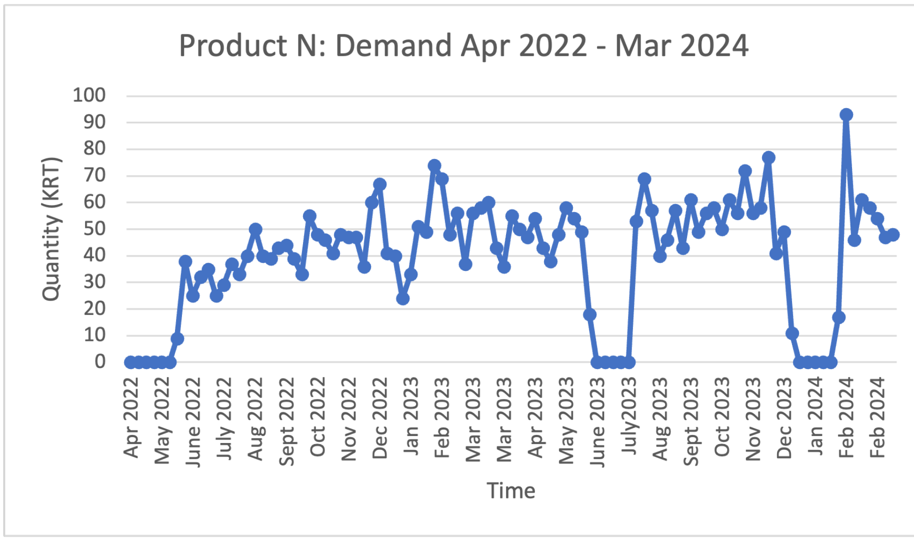
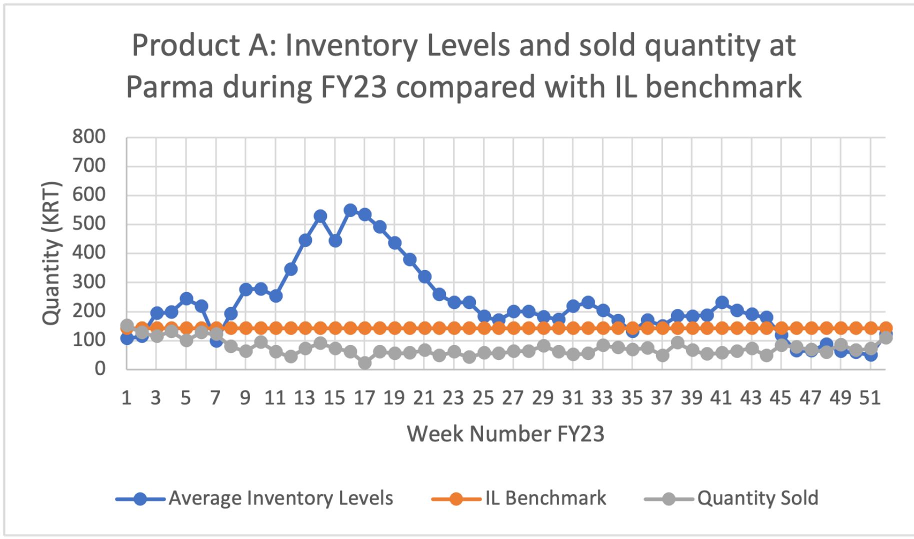


Figure A.8: Graphs of demand over the duration of its sales SL3 LT products.

A.5 Graphs Over Inventory Levels and Sold Quantity at Parma During FY23 Compared With Benchmark



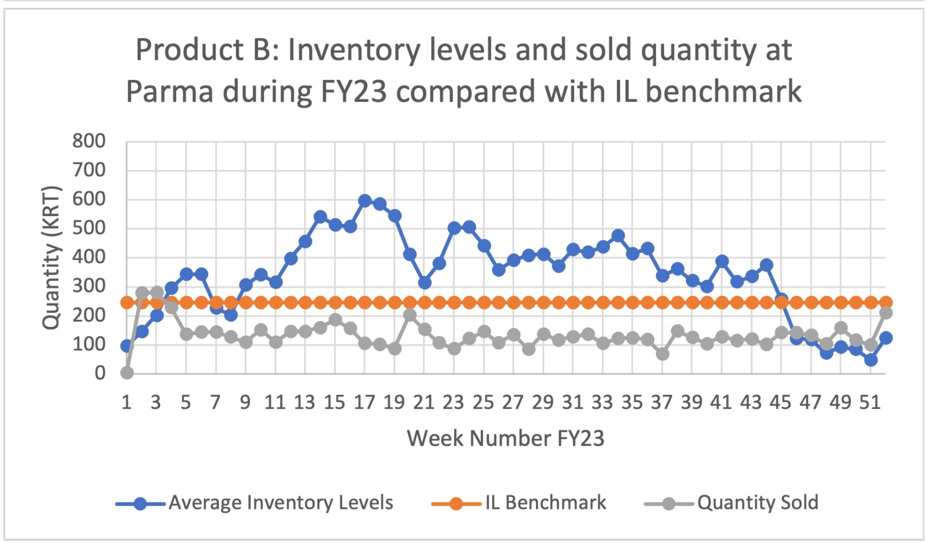


Figure A.9: Graphs over inventory levels and sold quantity during FY23 compared with the calculated IL benchmark for SL1 HT products.

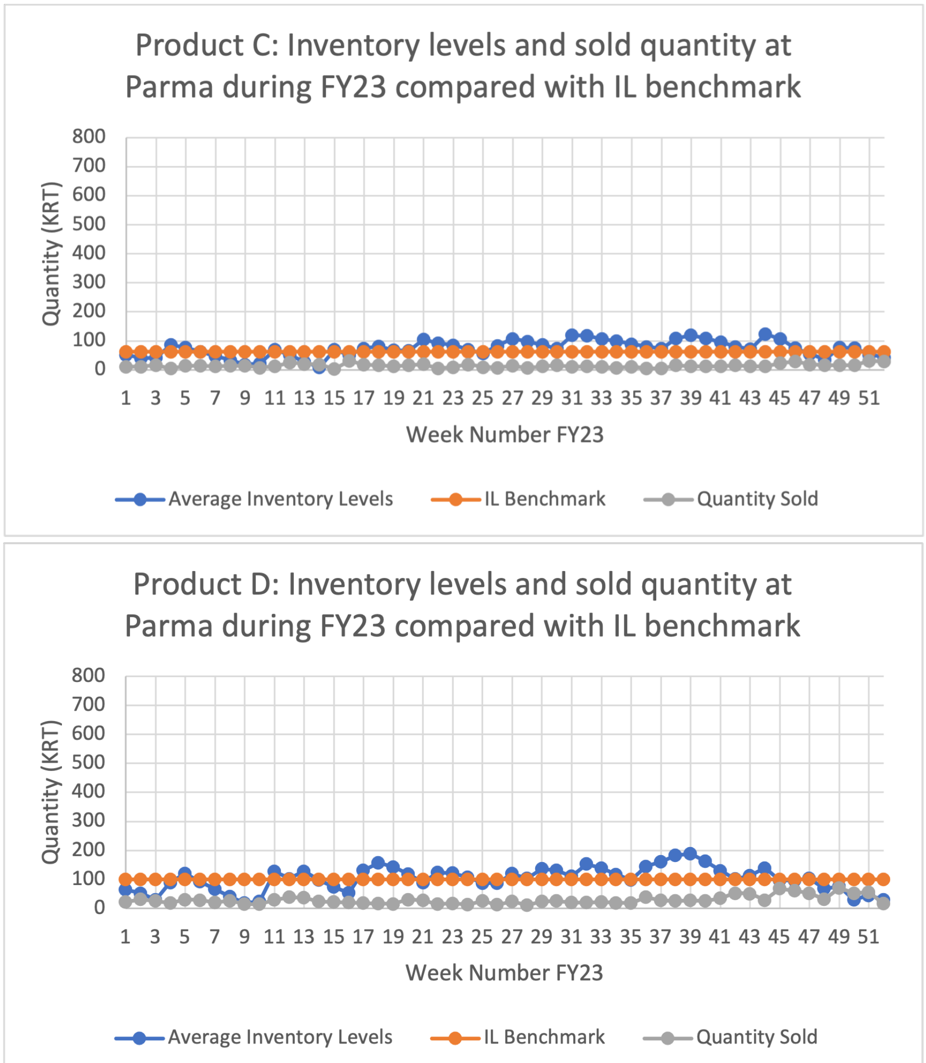
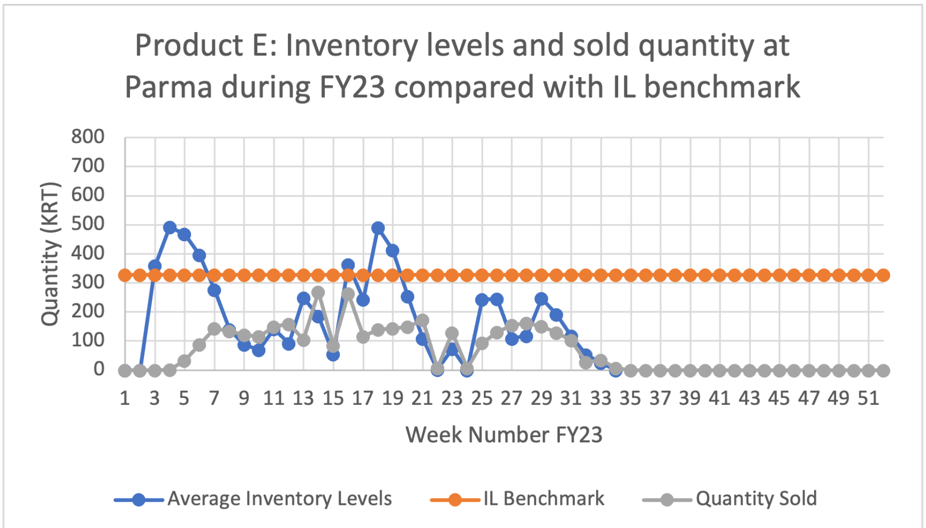


Figure A.10: Graphs over inventory levels and sold quantity during FY23 compared with the calculated IL benchmark for SL1 LT products.



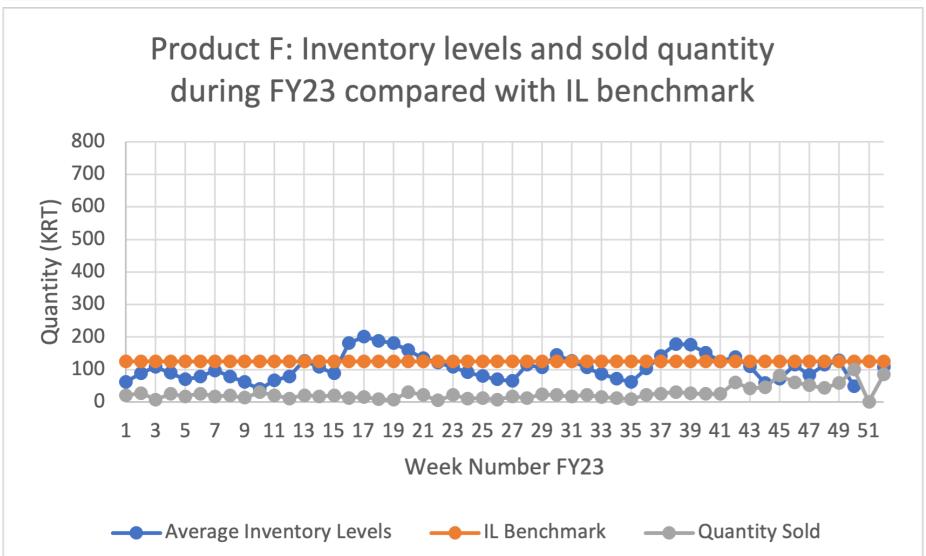


Figure A.11: Graphs over inventory levels and sold quantity during FY23 compared with the calculated IL benchmark for SL1 FD products.

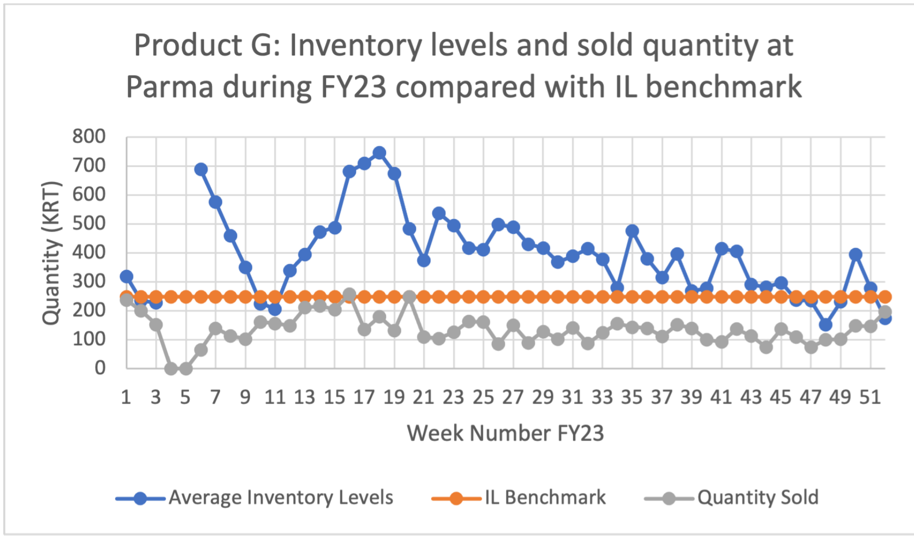
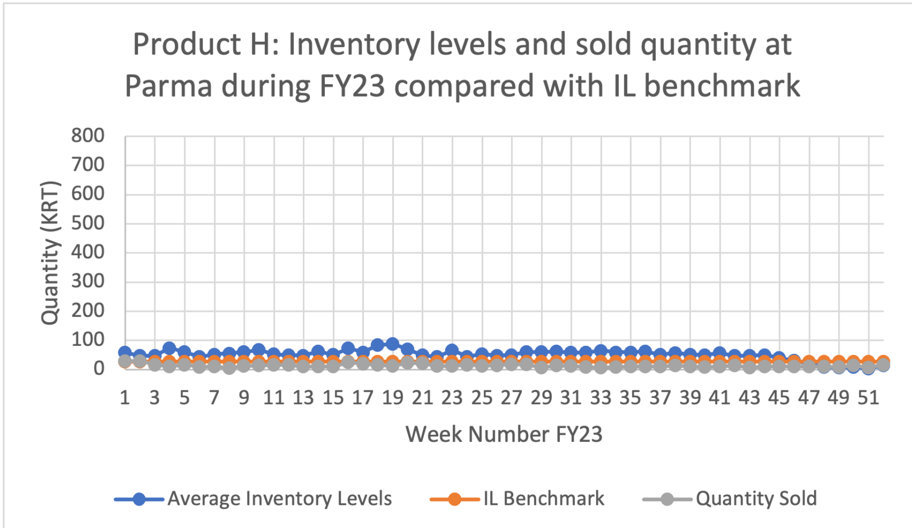


Figure A.12: Graphs over inventory levels and sold quantity during FY23 compared with the calculated IL benchmark for SL2 HT products.



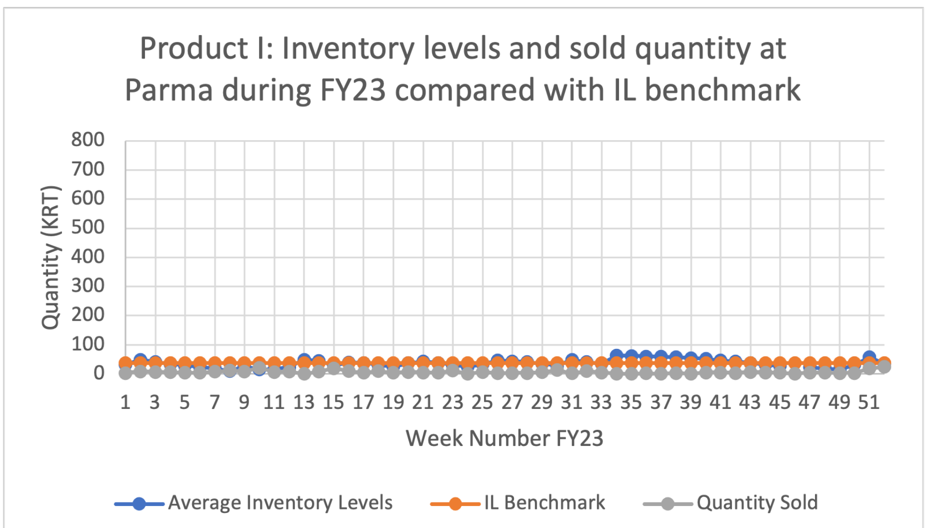
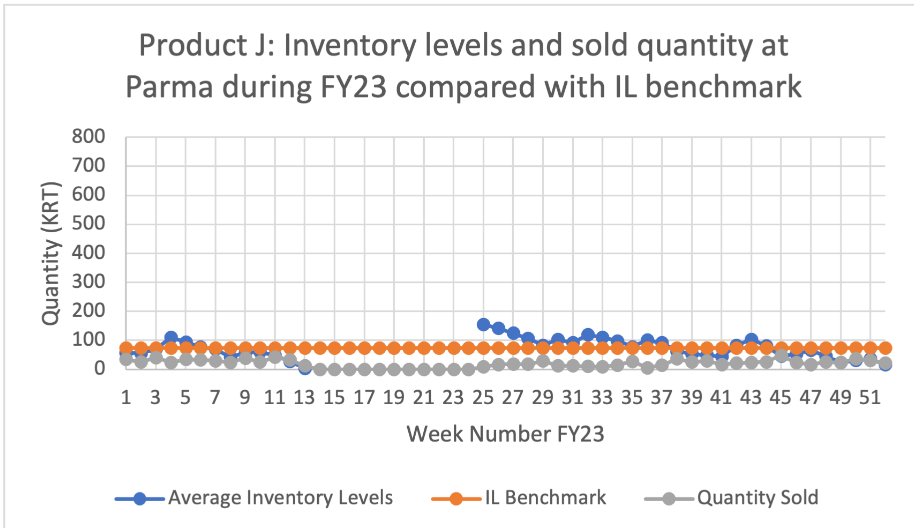


Figure A.13: Graphs over inventory levels and sold quantity during FY23 compared with the calculated IL benchmark for SL2 LT products.



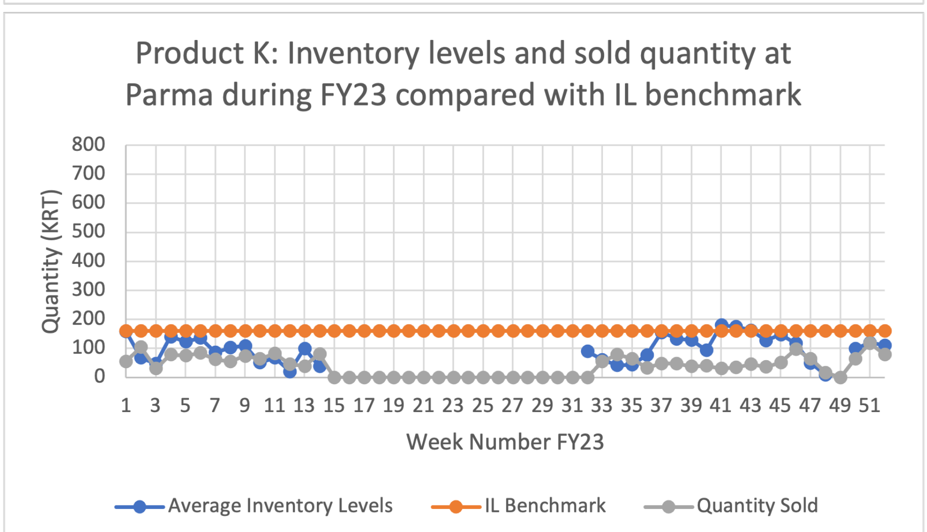


Figure A.14: Graphs over inventory levels and sold quantity during FY23 compared with the calculated IL benchmark for SL2 FD products.

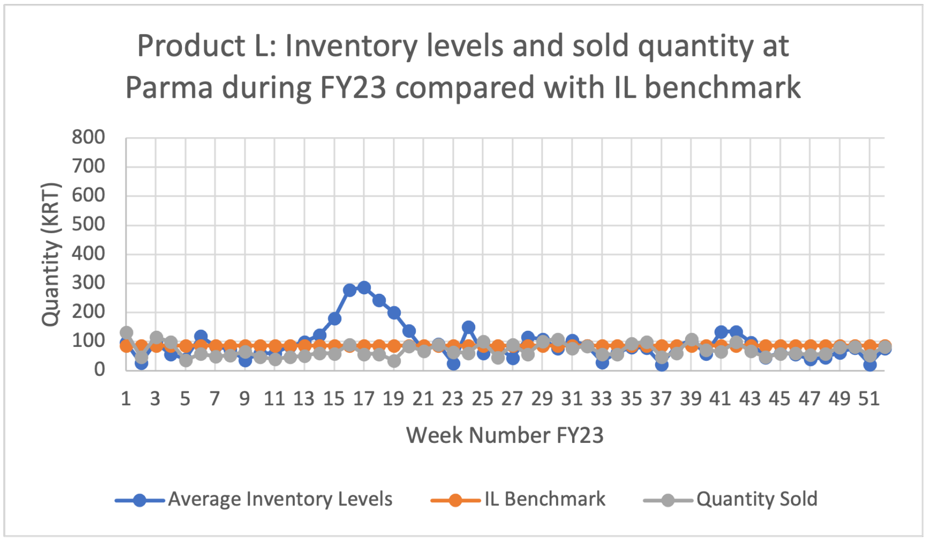


Figure A.15: Graphs over inventory levels and sold quantity during FY23 compared with the calculated IL benchmark for SL3 HT products.

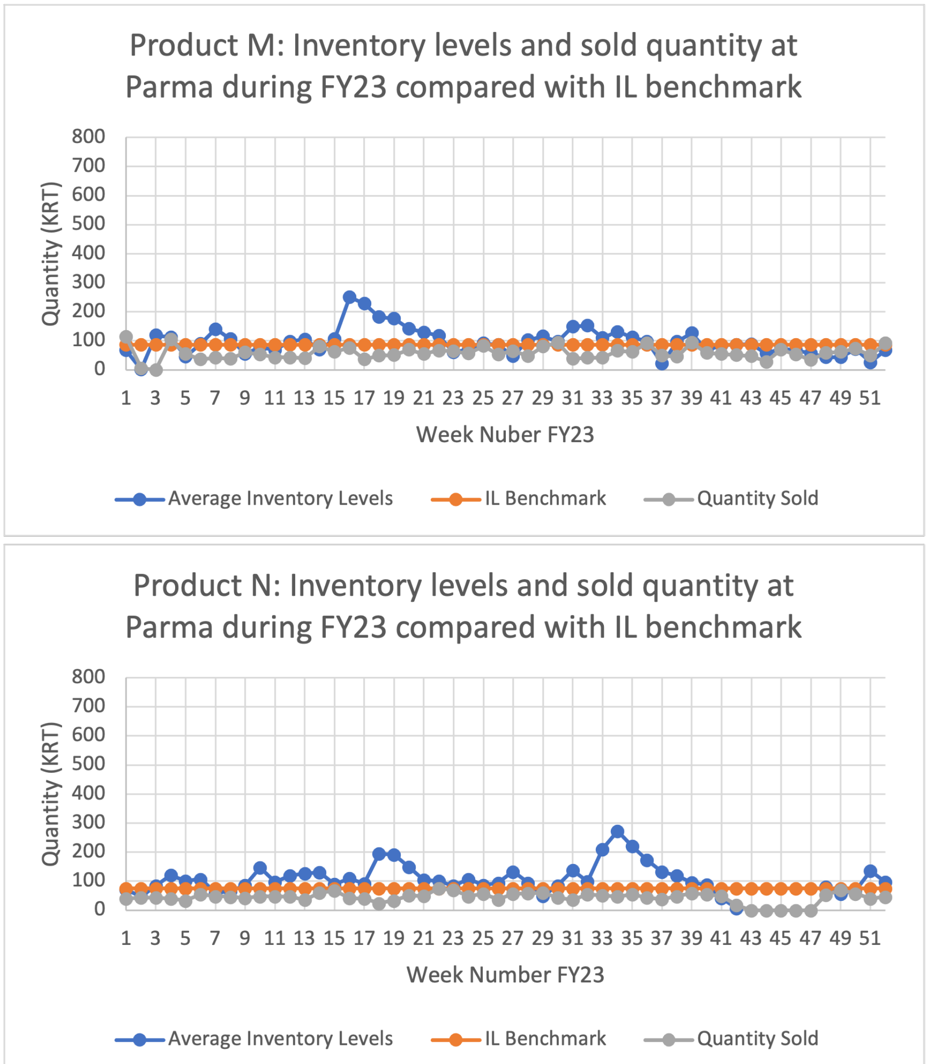
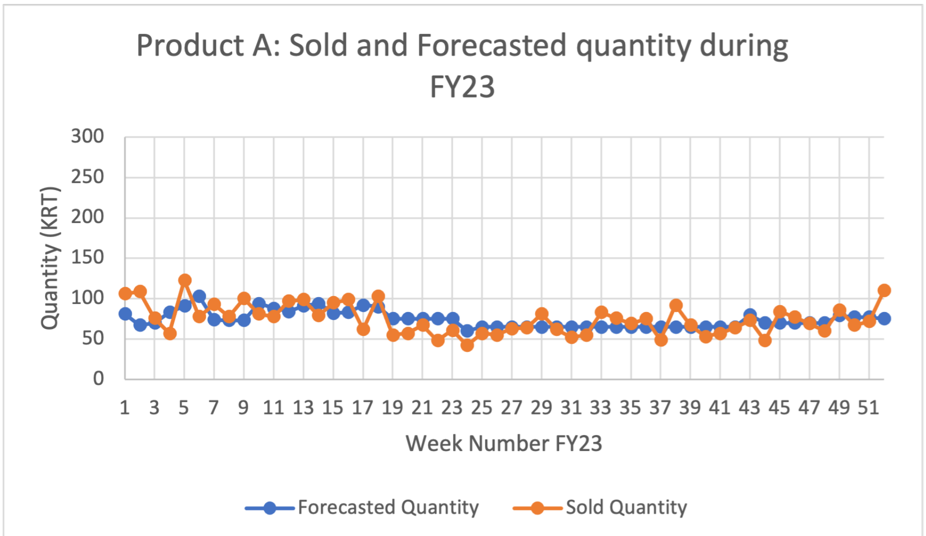


Figure A.16: Graphs over inventory levels and sold quantity during FY23 compared with the calculated IL benchmark for SL3 LT products.

A.6 Sold and Forecasted Quantity at Parma during FY23



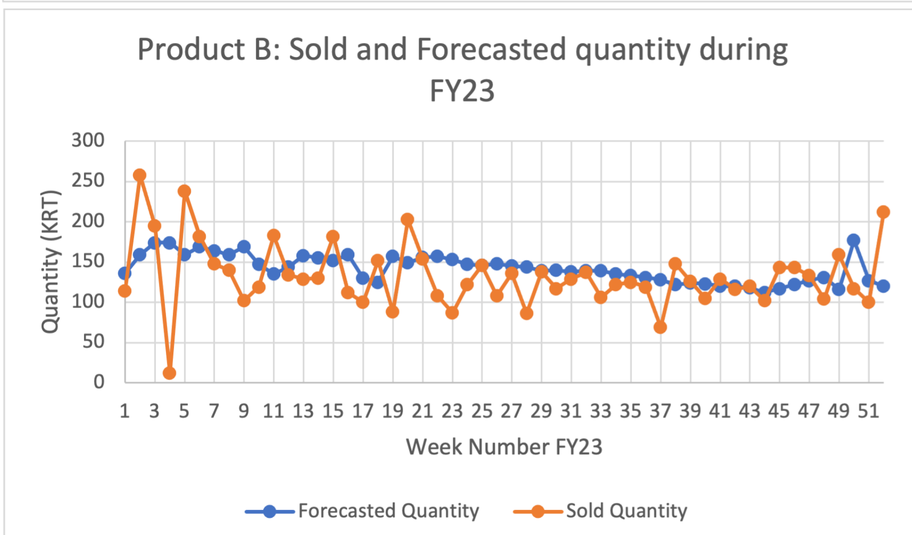
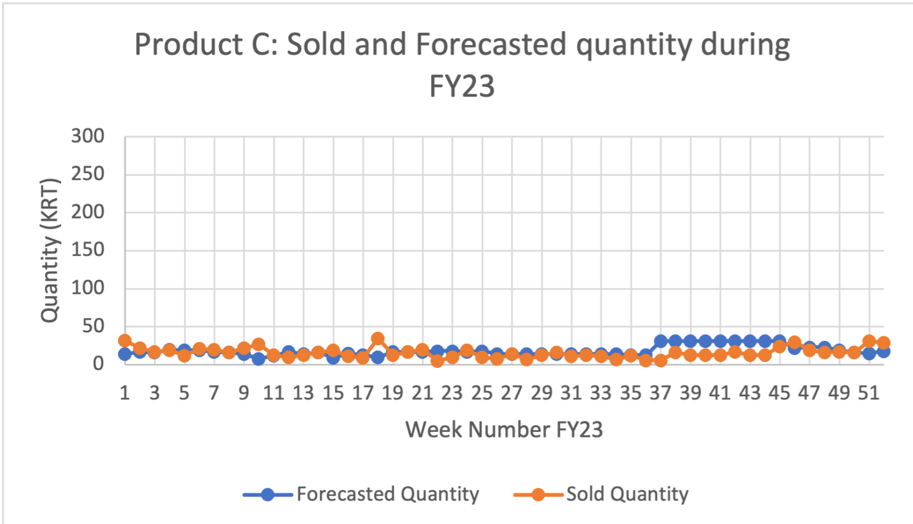


Figure A.17: Graphs over the sold and forecasted quantity at the RDC in Parma during FY23 for SL1 HT products.



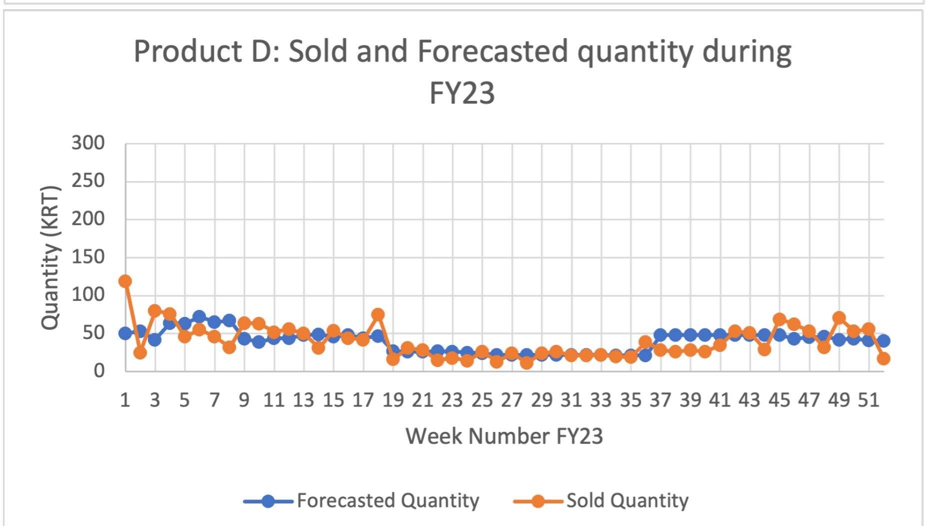
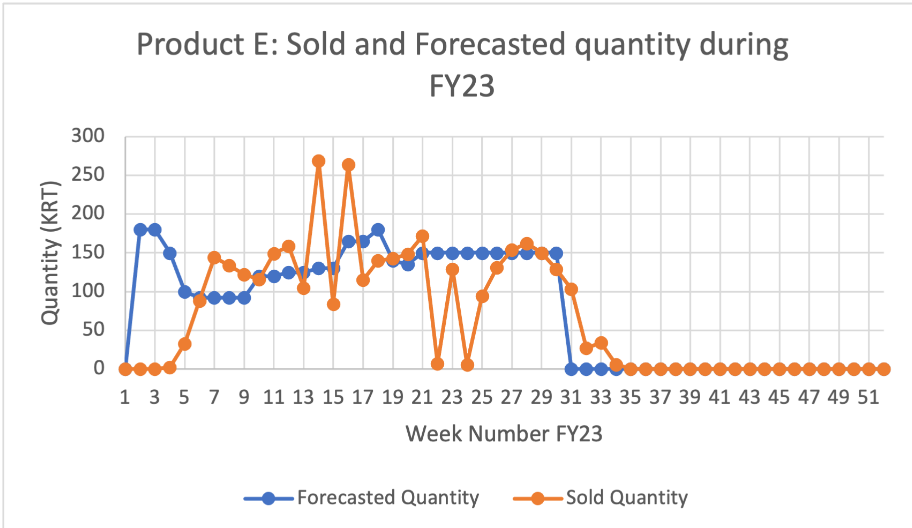


Figure A.18: Graphs over the sold and forecasted quantity at the RDC in Parma during FY23 for SL1 LT products.



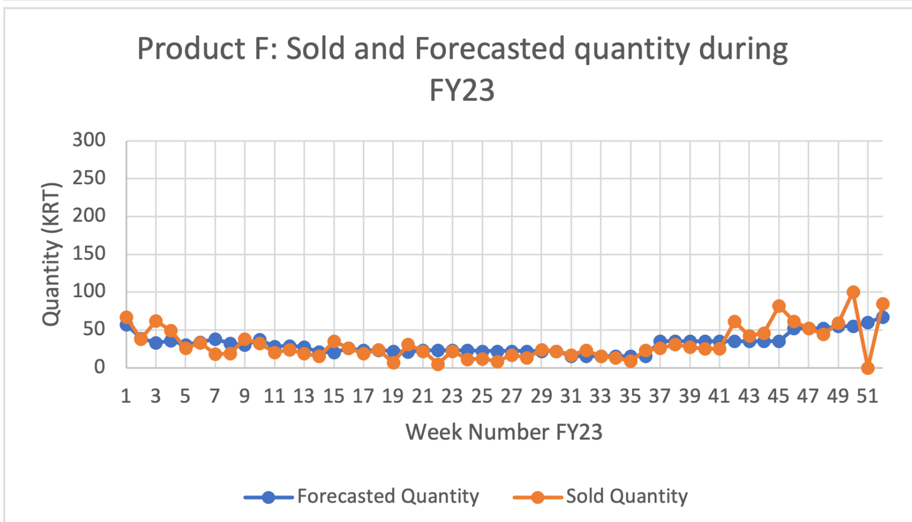


Figure A.19: Graphs over the sold and forecasted quantity at the RDC in Parma during FY23 for SL1 FD products.

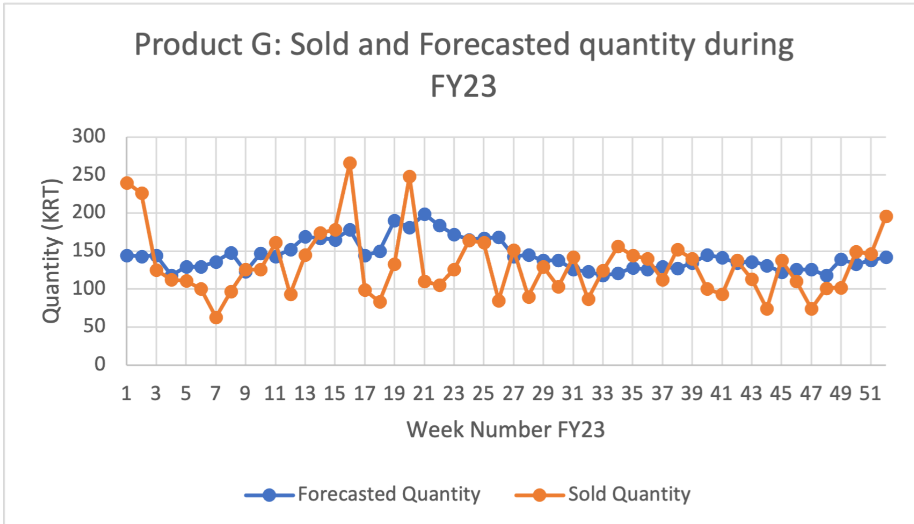
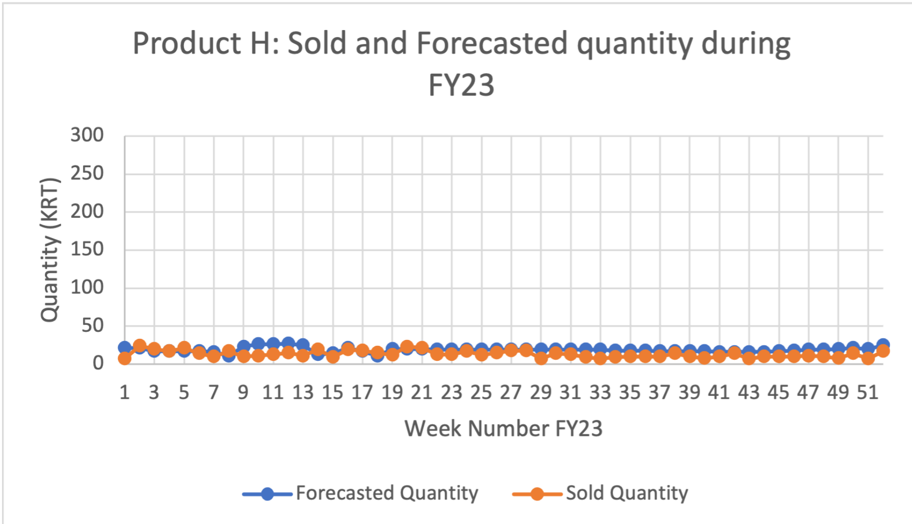


Figure A.20: Graphs over the sold and forecasted quantity at the RDC in Parma during FY23 for SL2 HT products.



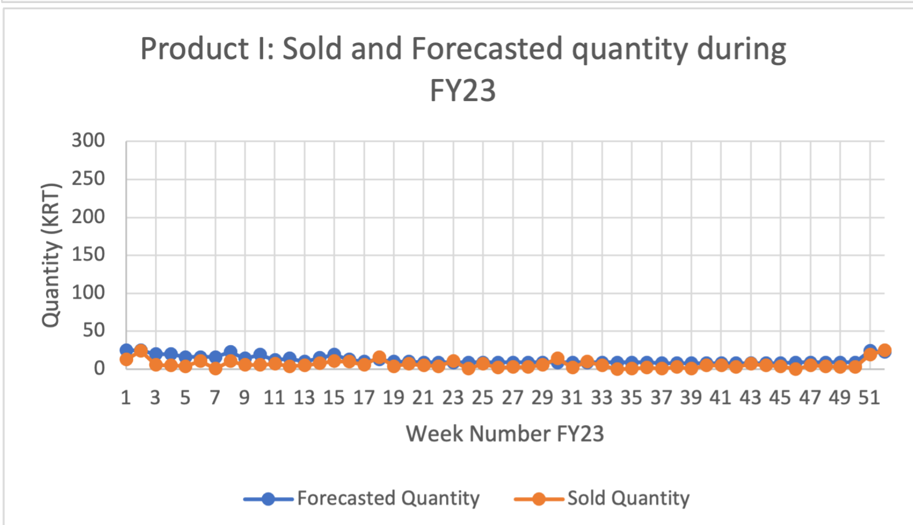
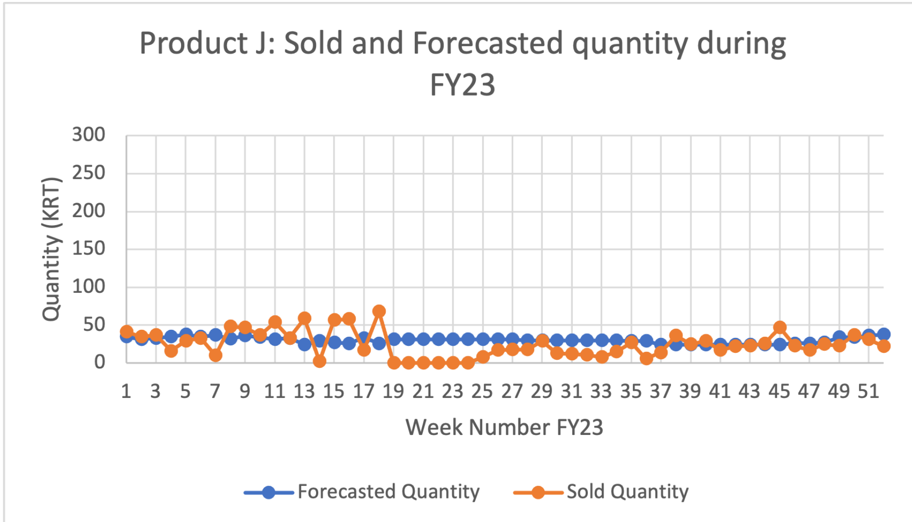


Figure A.21: Graphs over the sold and forecasted quantity at the RDC in Parma during FY23 for SL2 LT products.



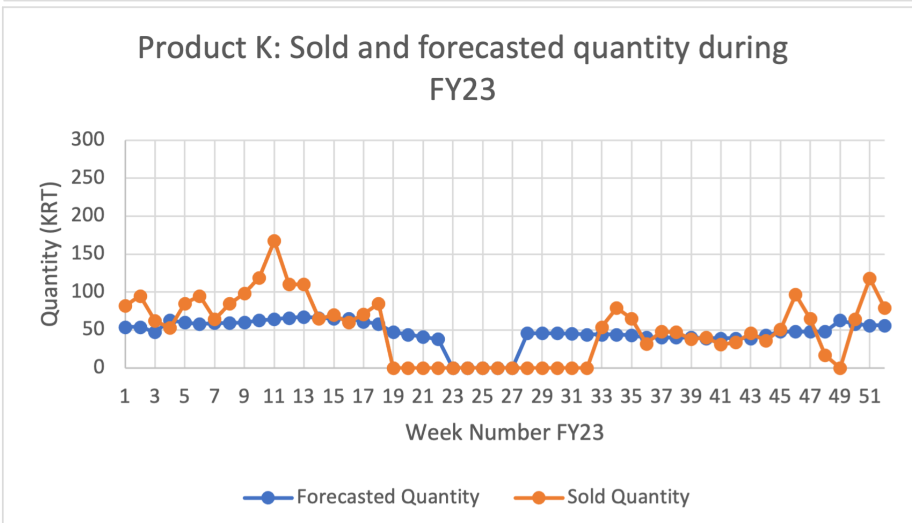


Figure A.22: Graphs over the sold and forecasted quantity at the RDC in Parma during FY23 for SL2 FD products.

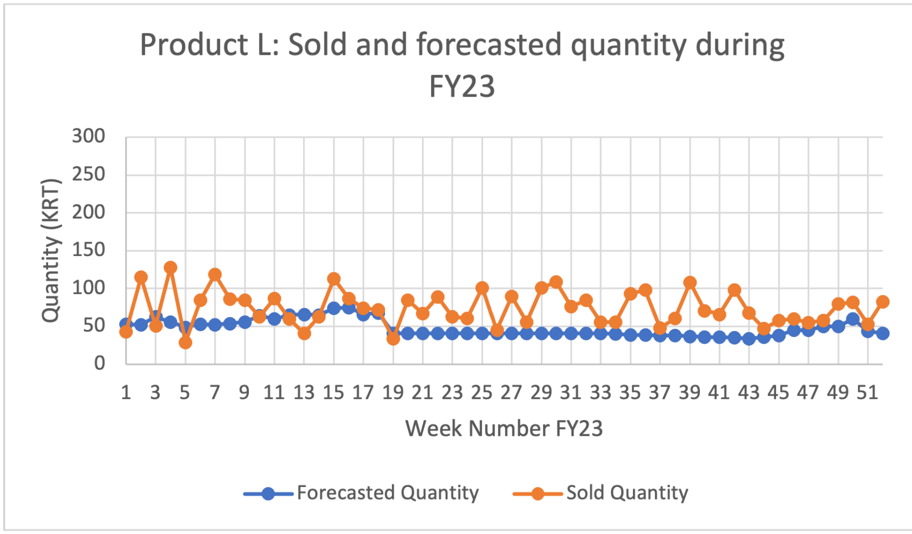
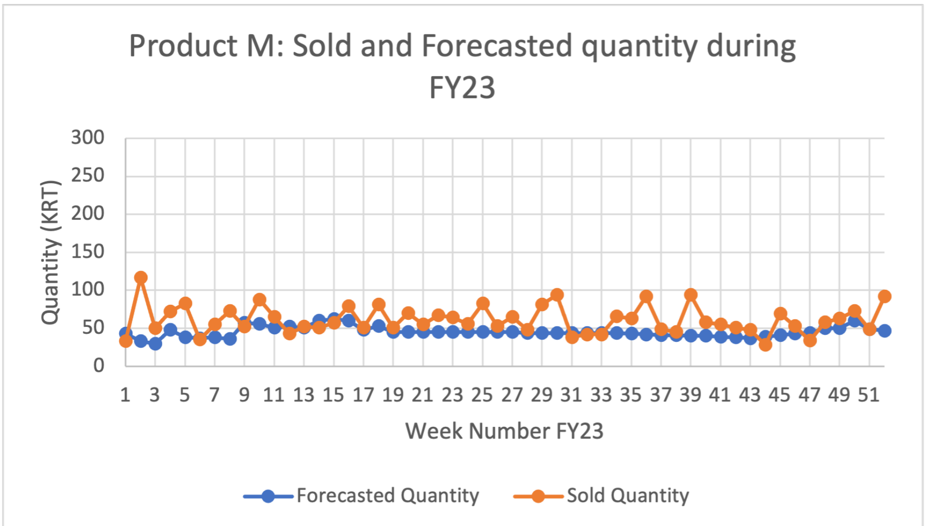


Figure A.23: Graphs over the sold and forecasted quantity at the RDC in Parma during FY23 for SL3 HT products.



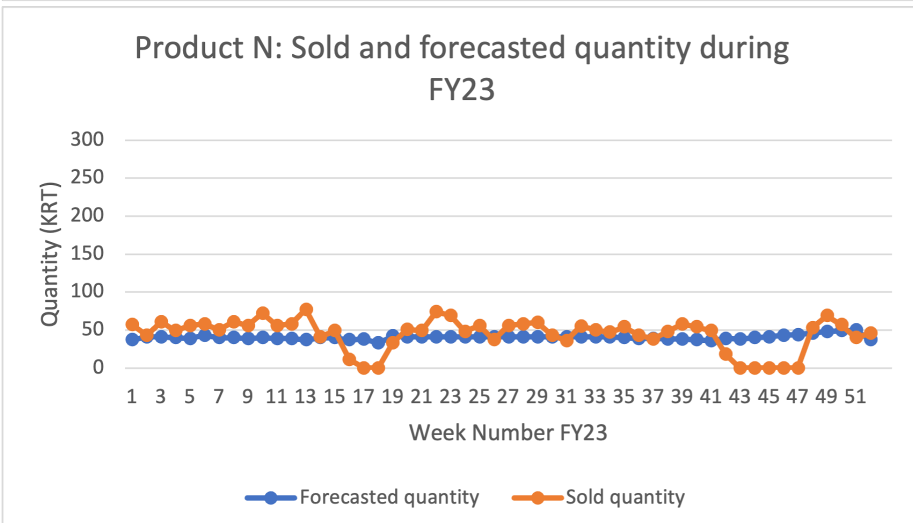
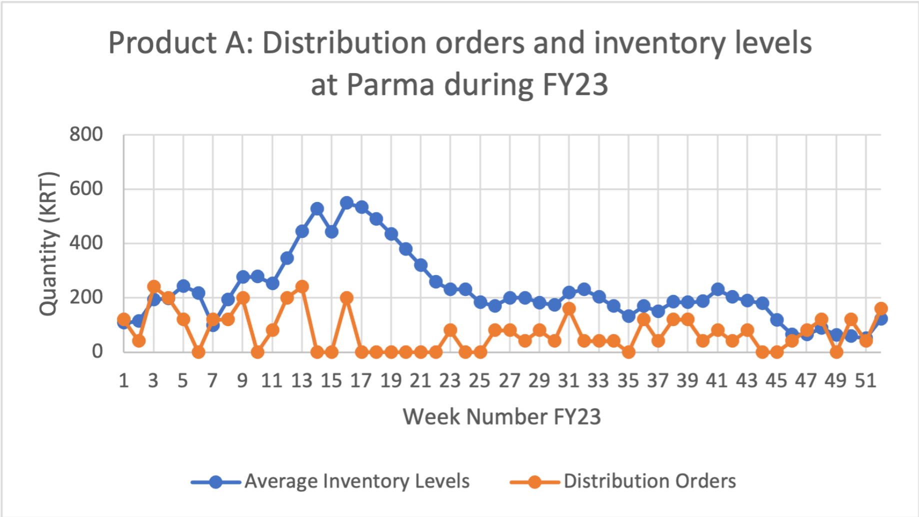


Figure A.24: Graphs over the sold and forecasted quantity at the RDC in Parma during FY23 for SL3 FD products.

A.7 Graphs Over Distribution Orders and Inventory Levels at Parma During FY23



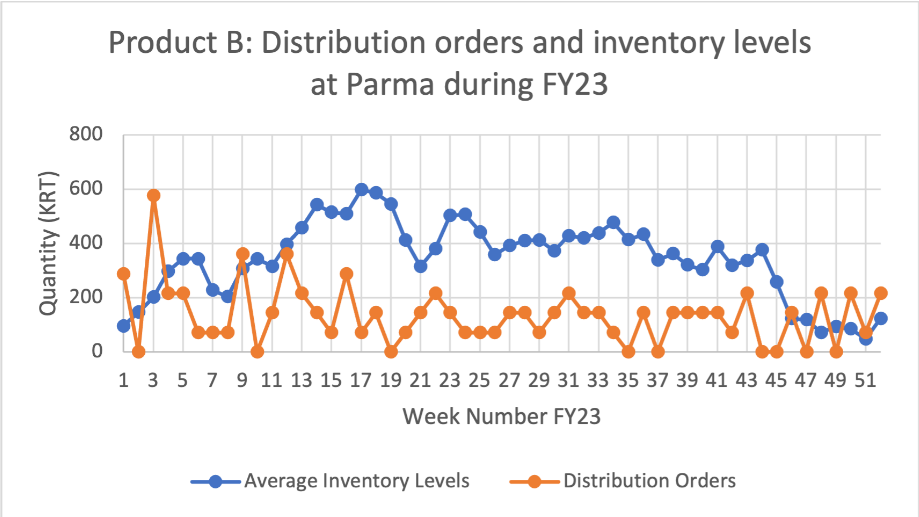


Figure A.25: Graphs over inventory levels and distribution orders at Parma during FY23 for SL1 HT products.

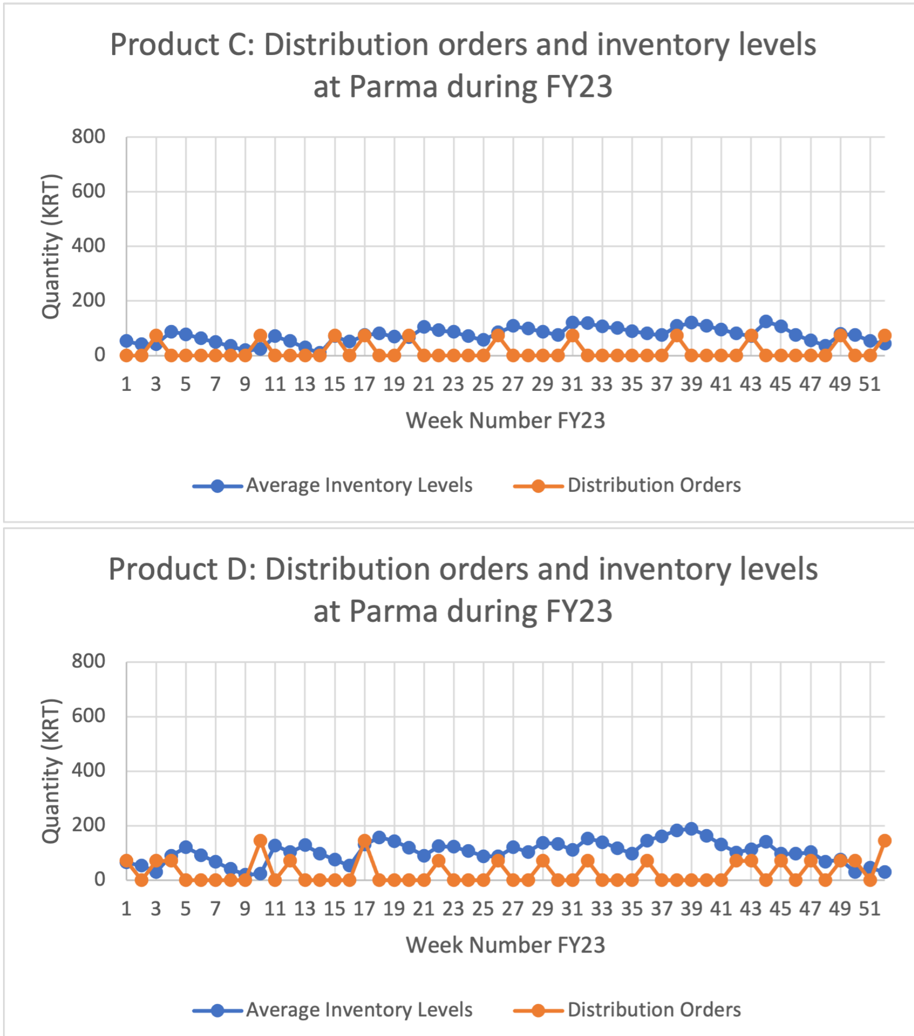
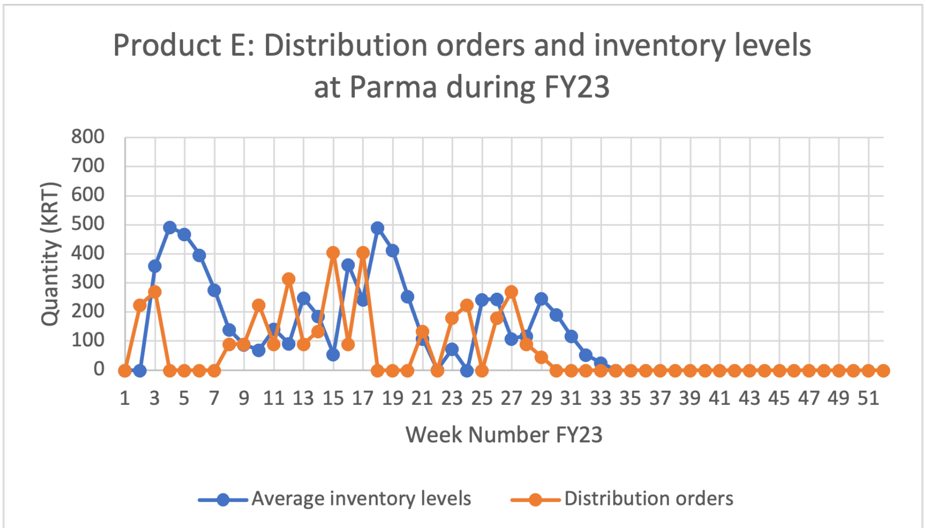


Figure A.26: Graphs over inventory levels and distribution orders at Parma during FY23 for SL1 LT products.



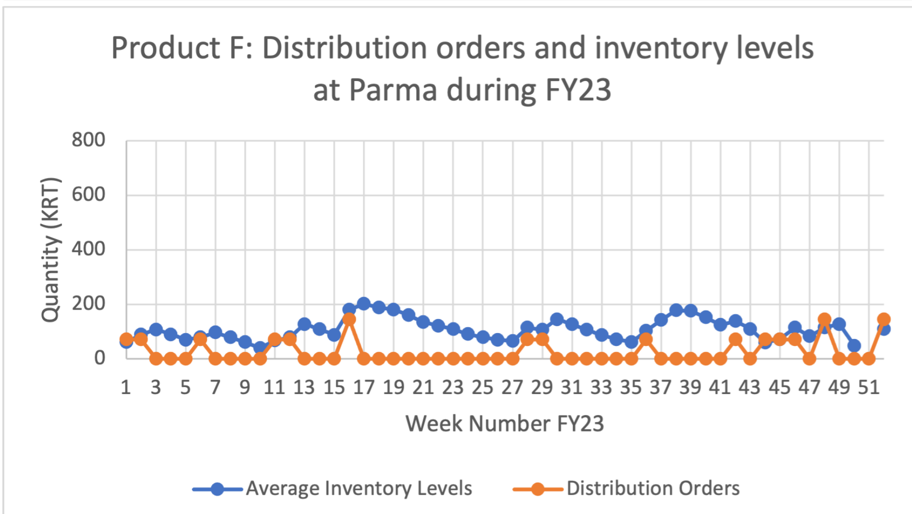


Figure A.27: Graphs over inventory levels and distribution orders at Parma during FY23 for SL1 FD products.

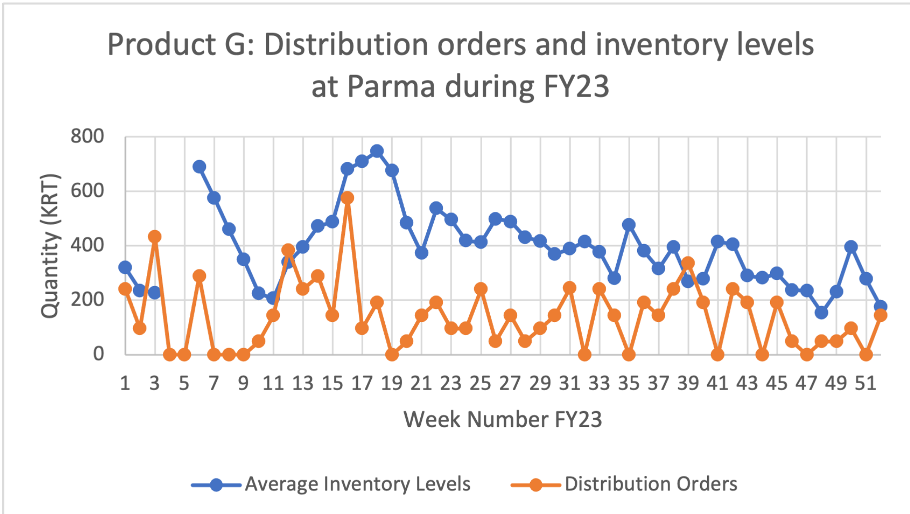
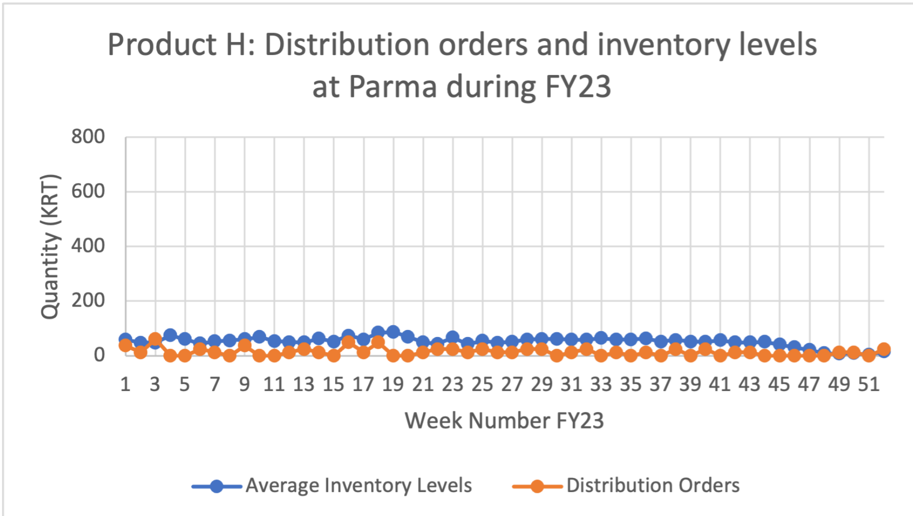


Figure A.28: Graphs over inventory levels and distribution orders at Parma during FY23 for SL2 HT products.



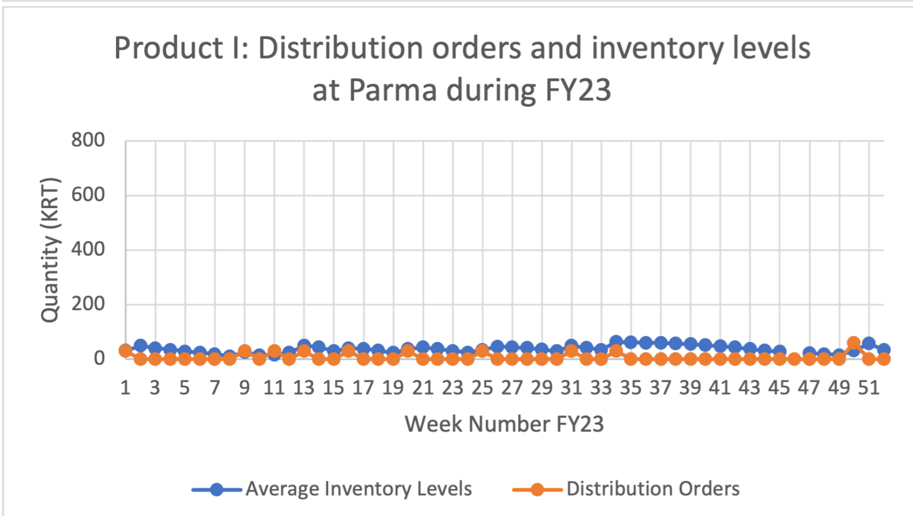


Figure A.29: Graphs over inventory levels and distribution orders at Parma during FY23 for SL2 LT products.

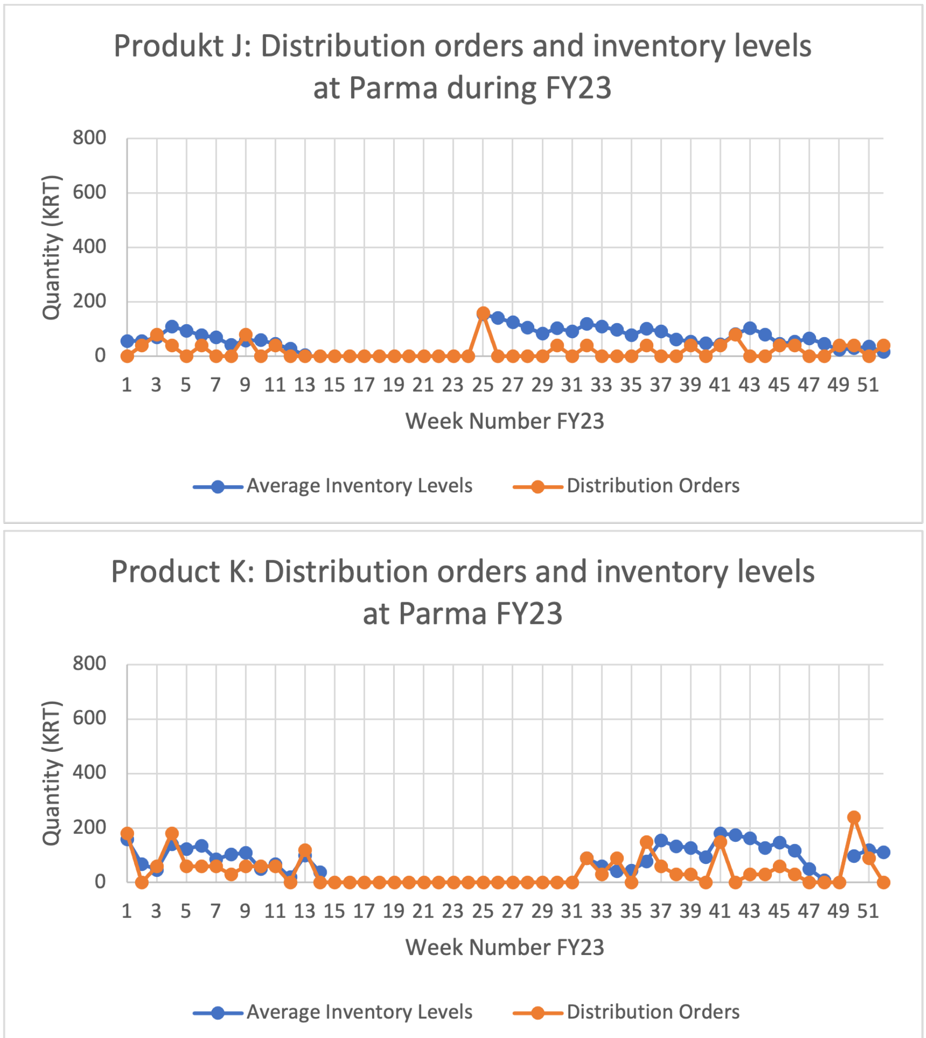


Figure A.30: Graphs over inventory levels and distribution orders at Parma during FY23 for SL2 FD products.

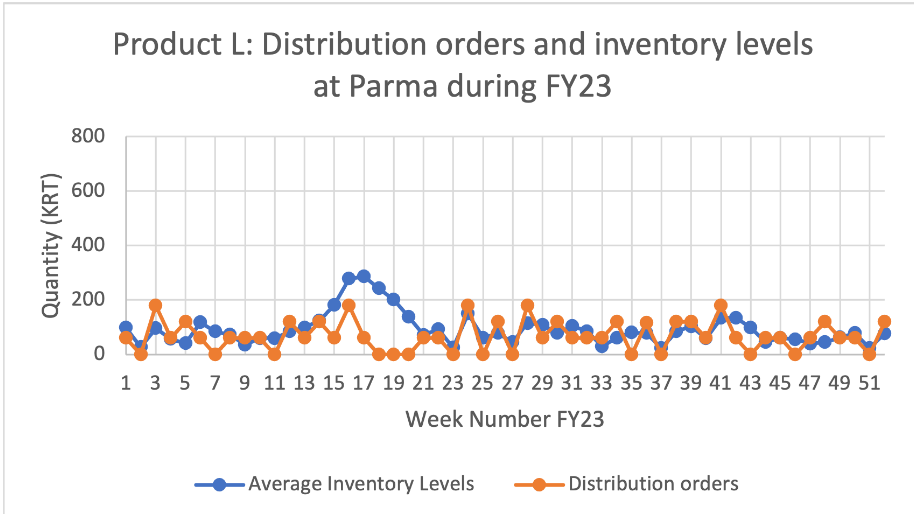
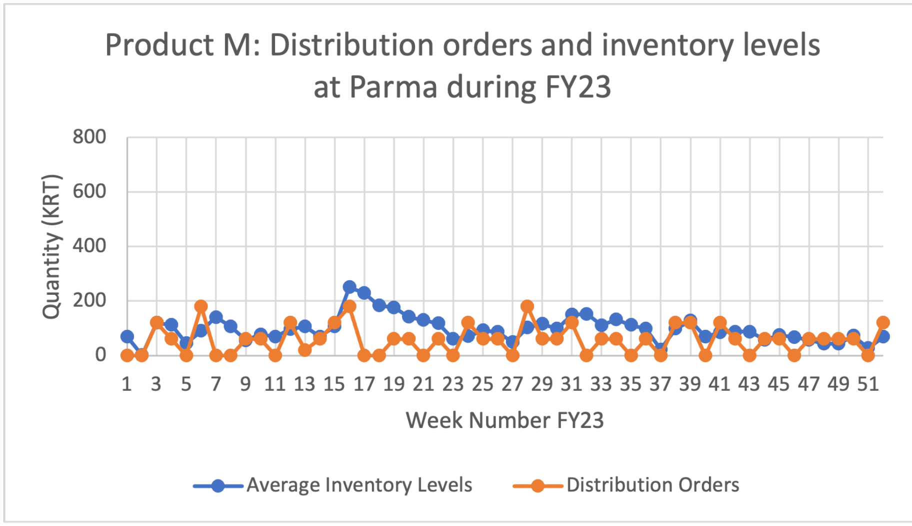


Figure A.31: Graphs over inventory levels and distribution orders at Parma during FY23 for SL3 HT products.



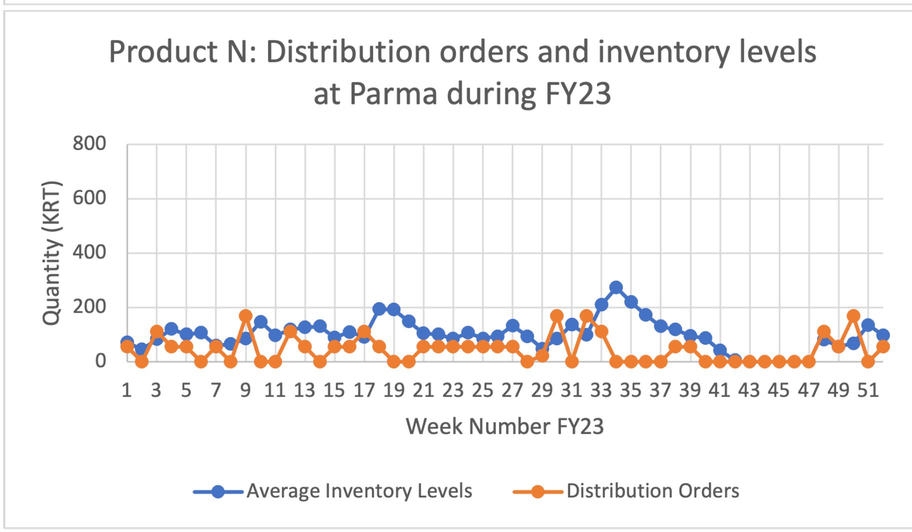
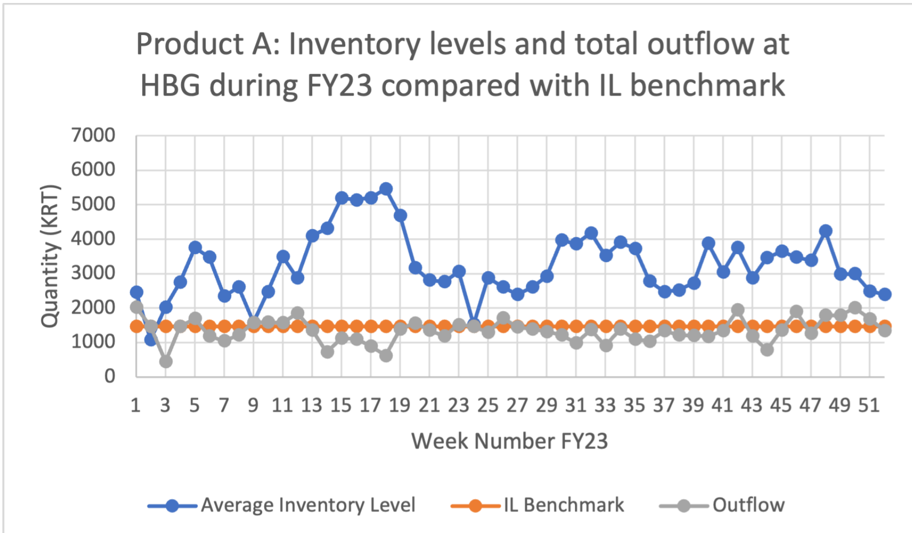


Figure A.32: Graphs over inventory levels and distribution orders at Parma during FY23 for SL3 LT products.

A.8 Graphs Over Inventory Levels and Outflow at Helsingborg During FY23 Compared With Benchmark



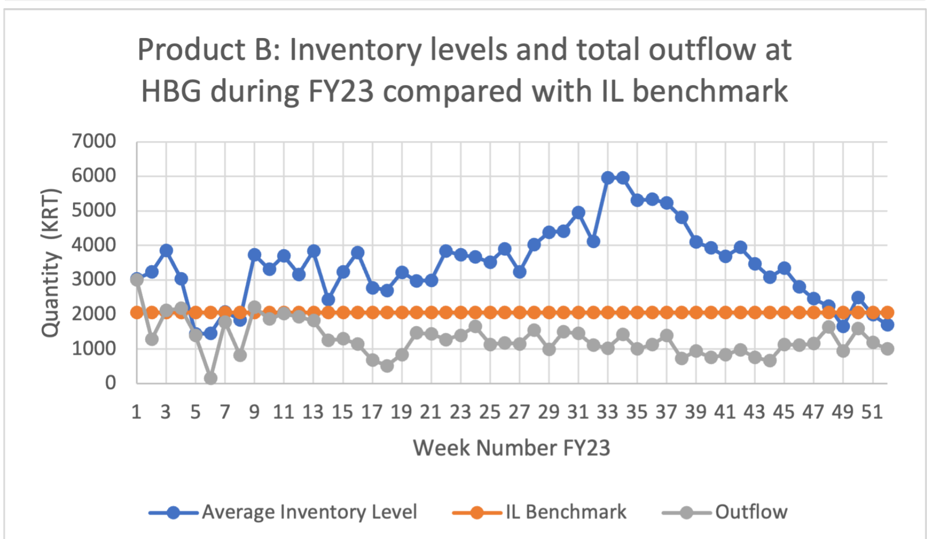
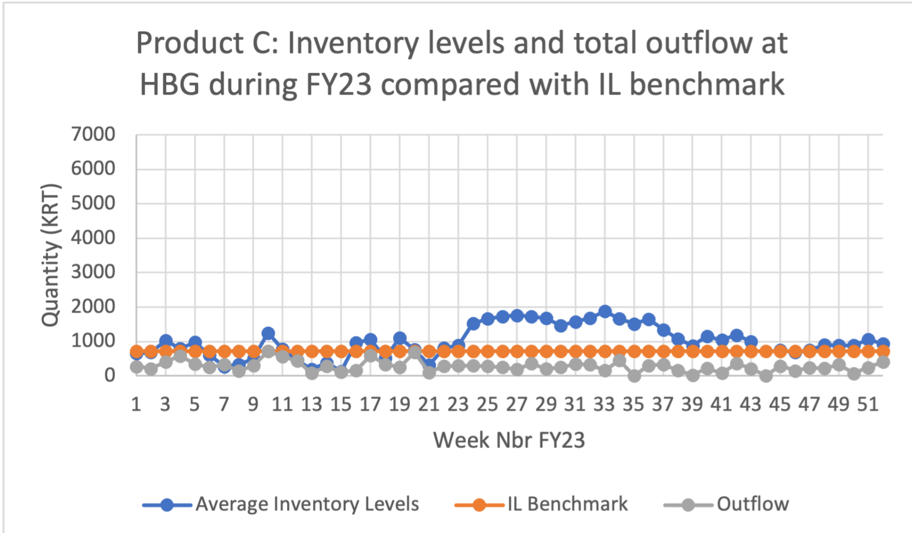


Figure A.33: Graphs over inventory levels and outflow at HBG during FY23 compared with the calculated IL benchmark for SL1 HT products.



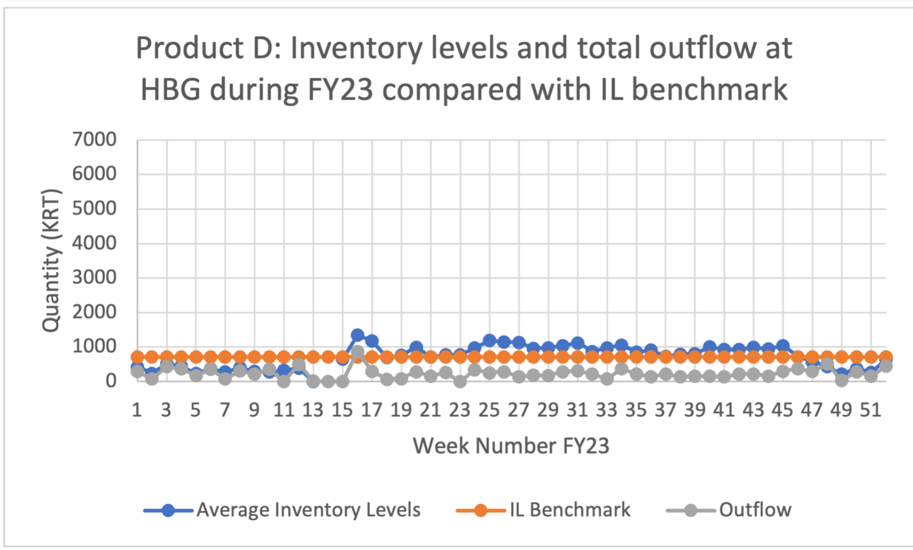
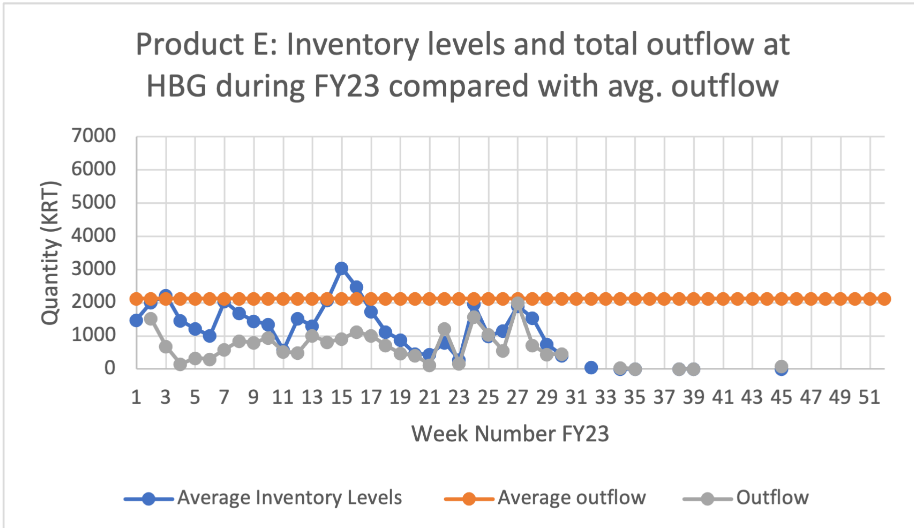


Figure A.34: Graphs over inventory levels and outflow at HBG during FY23 compared with the calculated IL benchmark for SL1 LT products.



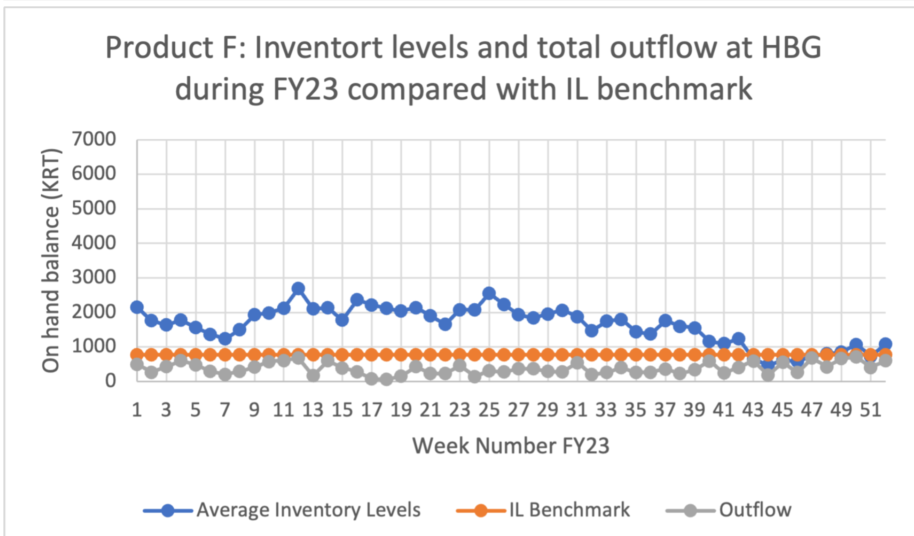


Figure A.35: Graphs over inventory levels and outflow at HBG during FY23 compared with the calculated IL benchmark for SL1 FD products.

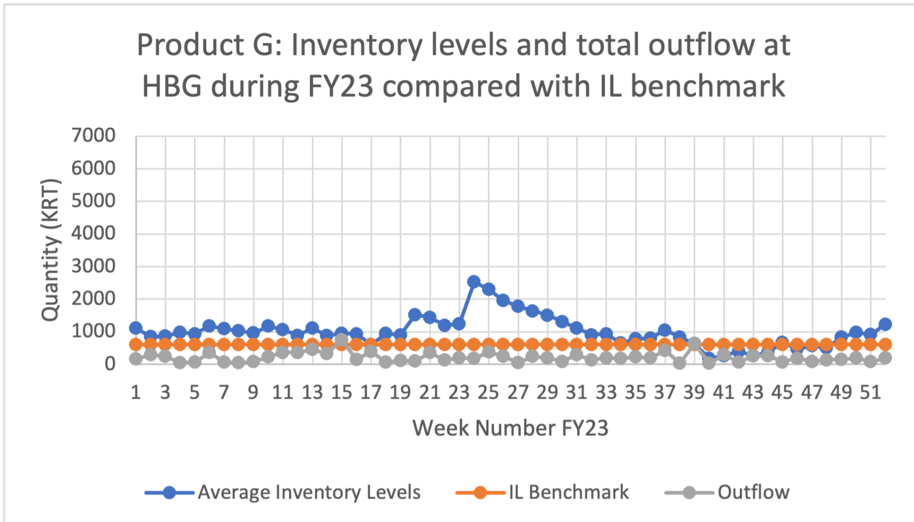
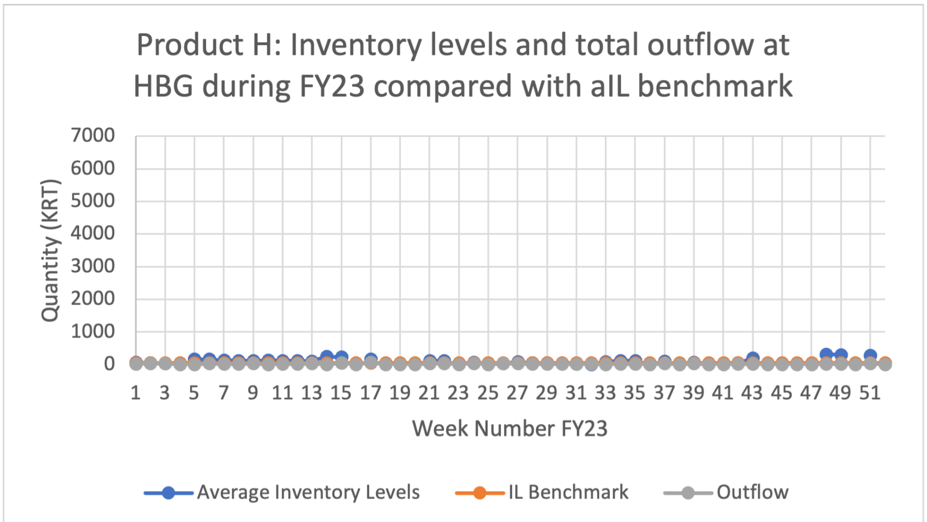


Figure A.36: Graphs over inventory levels and outflow at HBG during FY23 compared with the calculated IL benchmark for SL2 HT products.



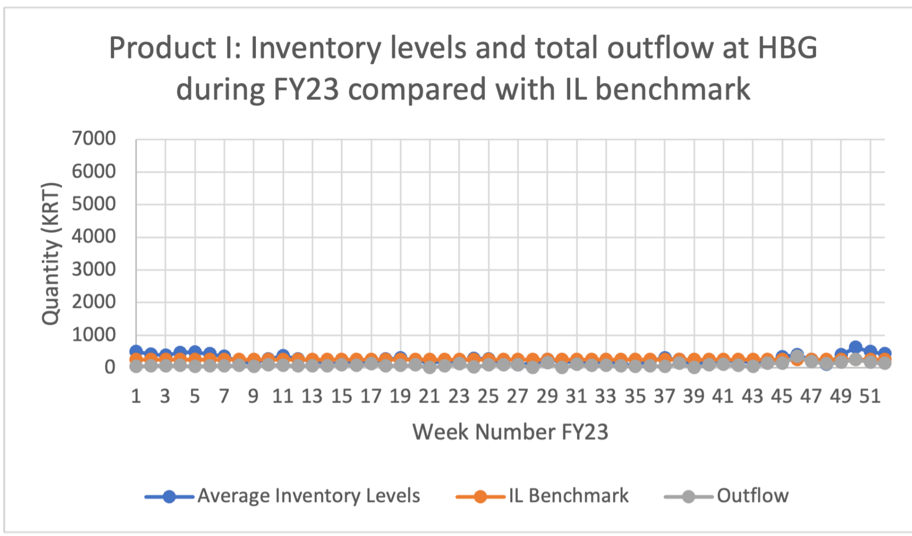
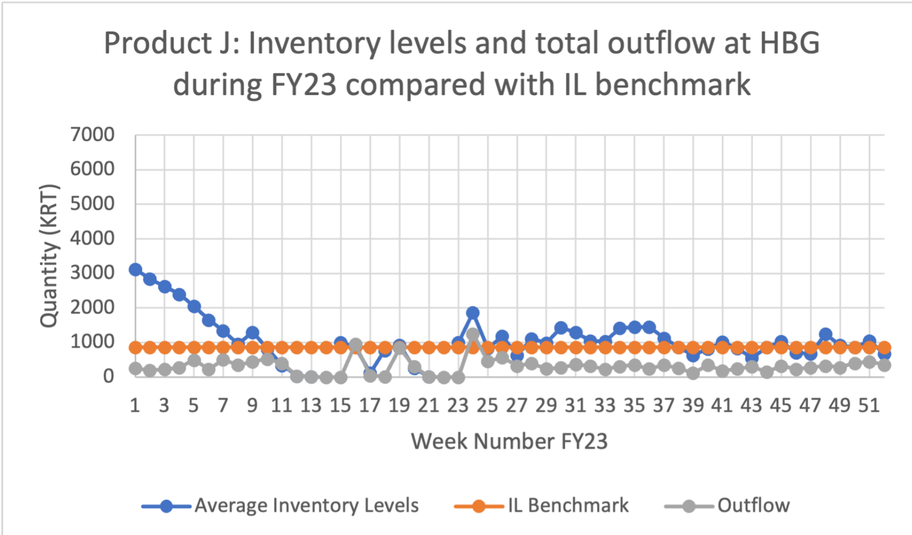


Figure A.37: Graphs over inventory levels and outflow at HBG during FY23 compared with the calculated IL benchmark for SL2 LT products.



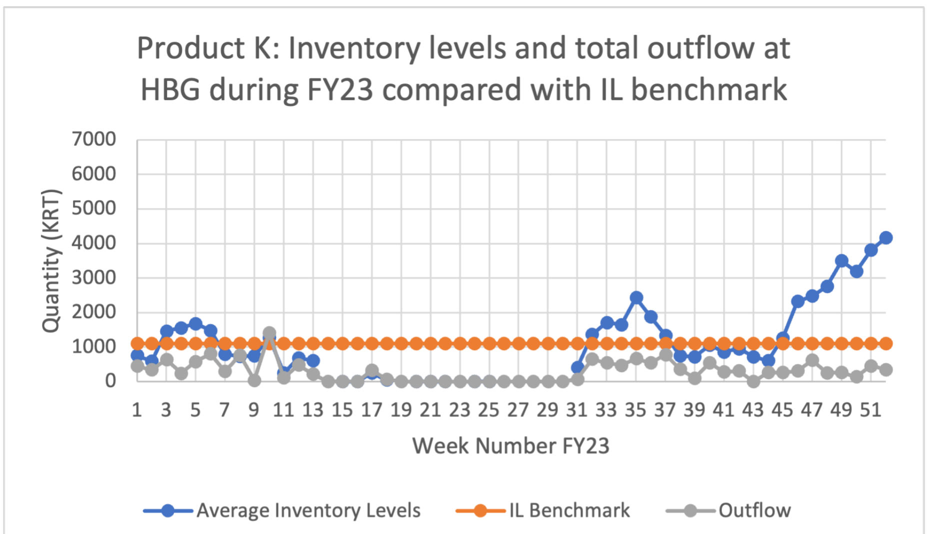


Figure A.38: Graphs over inventory levels and outflow at HBG during FY23 compared with the calculated IL benchmark for SL2 FD products.

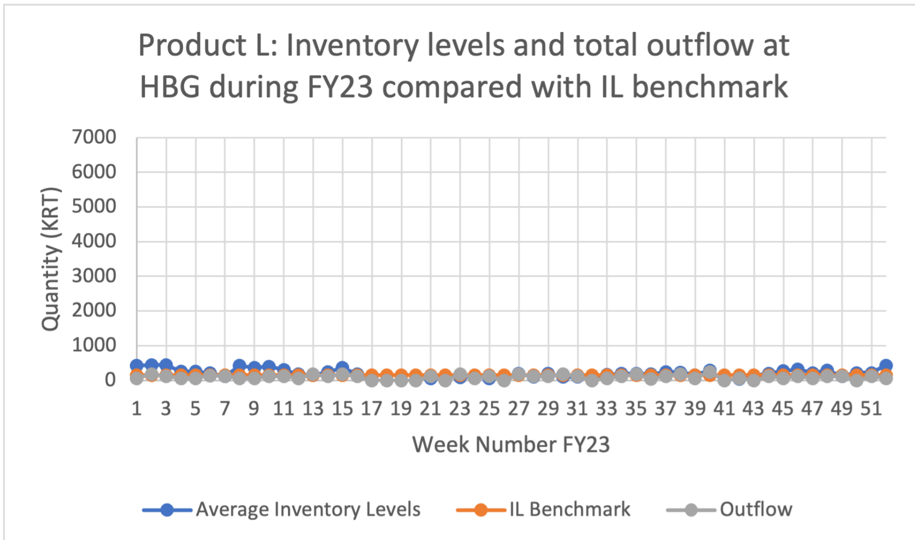
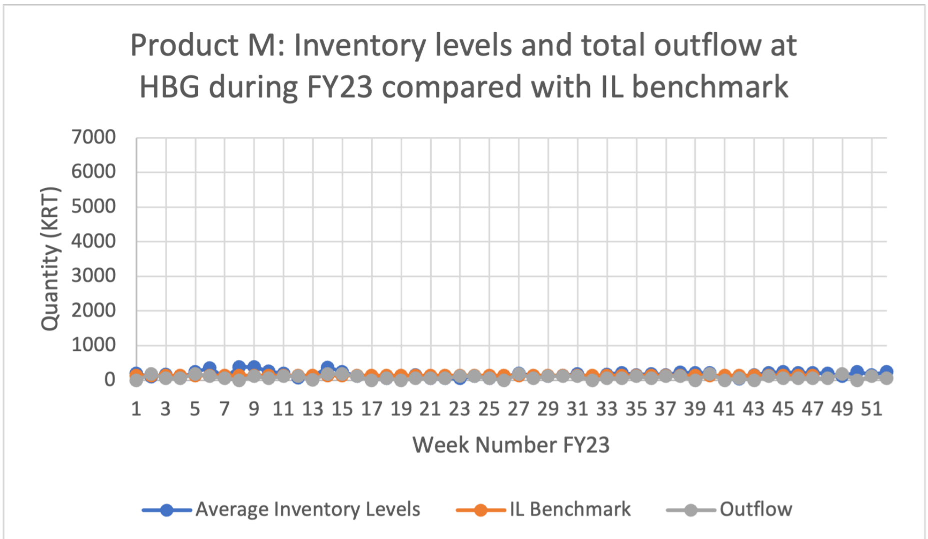


Figure A.39: Graphs over inventory levels and outflow at HBG during FY23 compared with the calculated IL benchmark for SL3 HT products.



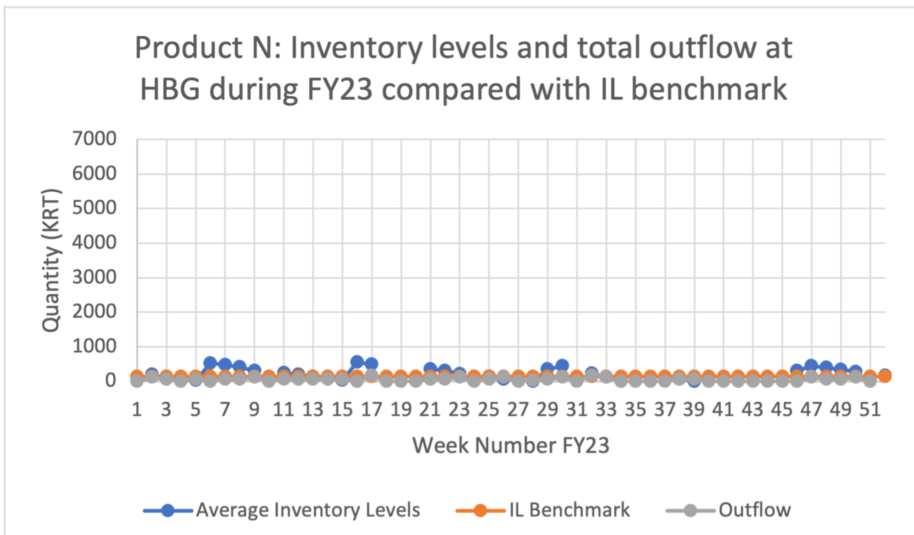


Figure A.40: Graphs over inventory levels and outflow at HBG during FY23 compared with the calculated IL benchmark for SL3 LT products.

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