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Enhancing the Business Environment Efficiency Through Data Sharing in Product Lifecycle Management

Degree Project in Production Management

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Preface

This thesis at advanced level has been the pinnacle of my five years of studies in Industrial Engineering and Management at the Faculty of Engineering, LTH, at Lund University. Firstly, I would like to express my gratitude to my supervisor Bertil I Nilsson for all his advice and the encouragement that he has poured into me. It has helped me stay on my toes as I've written this paper myself.

Secondly, I would like to thank the case company, Tetra Pak, for this opportunity and especially my company supervisors Lars Sickert and Peter Lundgren. They have always treated me very warmly and I have always felt welcome. It has been very rewarding.

Lastly, I want to thank my family and friends for enduring listening to all my talk about this paper. Now you don't have to.

Lund, May 2024
Otto Stenram

Abstract

In the constantly changing environment in which companies operate, it is important to be able to optimize various activities throughout the product lifecycle. This places great demands on companies and their value chain, where information exchanges are central to activities. There are risks and rewards, such as the risk of losing intellectual property and unlocking new business cases, that comes from sharing product data between stakeholders.

The project objective is to identify how data sharing in Product Lifecycle Management can enhance the business environment efficiency of a company.

Qualitative data has been gathered to conduct this case study through 14 interviews at Tetra Pak. One additional interview was performed with an employee of another multinational company, with the aim of validating the transferability of the findings. An abductive approach was used to analyze the findings, which resulted in an interpretation of digital debt and Hill's model.

Sharing product data with suppliers and customers in one's business environment is proposed to be considered as an enabler. As a result, business cases are brought to the surface, which in turn can advance the company if executed properly. In this way, the company can maintain a cutting-edge position ahead of competitors in a business environment that is constantly changing.

At the same time, it is important to keep a fine balance between exposing product data and protecting it. It is therefore crucial to implement changes gradually in a standardized manner that also integrates well with other activities. This way, the risk of changes going amiss is minimized.

List of Abbreviations

PLM	Product Lifecycle Management
BOM	Bill of Materials
EBOM	Engineering Bill of Materials
MBOM	Manufacturing Bill of Materials
SBOM	Sales Bill of Materials
ASBOM	As Shipped Bill of Material
AMBOM	As Maintained Bill of Material
ERP	Enterprise Resource Planning
CRM	Customer Relationship Management
KB	Knowledge Base
CAD	Computer Aided Design
PIV	Product Information Viewer
PDM	Product Data Management
PSE	Processing Solutions & Equipment
BOL	Beginning of Life
MOL	Middle of Life
EOL	End of Life
CE	Concurrent Engineering
MRP	Material Requirements Planning
MRP II	Manufacturing Resource Planning
DfD	Design for Disassembly

Definitions

Business Environment	The total sum of all external and internal factors that influence a business. This includes for instance employees, suppliers, customers, owners, and activities by government.
Business Ecosystem	The purposeful business arrangement between two or more entities to create and share in collective value for a common set of customers.
Value Chain	The series of consecutive steps that go into the creation of a finished product.
Intellectual Property	An intangible and created asset of the human intellect, such as technical or scientific creation.
Operations	Business processes that occur to refine value from assets and thus enable a company to operate.

List of Figures

Figures without any reference are developed by the author.

Table of Contents

1. Introduction

The purpose of this chapter is to deliver an introduction to the subject of this master thesis. A brief background of Product Lifecycle Management and the role of product data sharing will be addressed along with the problem that forms the basis of this research. The research questions will be introduced and finally, the thesis outline will be presented.

1.1 Background

Product know-how in the form of product data or information is one of the most valuable resources for a company. This kind of data used to be in paper format which made it difficult to access and transport. However, by the year 2010, the majority of data was electronic which made it increasingly easier to access and to communicate. The result was that companies now require an intellectual property vault to protect it, since the global competition is increasing along with the potential risks of economic espionage (Stark, 2022).

Global competition brings changes to the product environment that a company operates within. In its turn, it affects the business environment which enables the company to implement new business models and strategies, which could be troublesome for firms operating in more traditional manners. Some companies decide to outsource their production to other companies, for the purpose of concentrating more on product development or marketing instead (Stark, 2022). This increases the complexity of the business environment in the form of more suppliers and dependent partnerships. To maintain one's competitive position, there is a need for a robust and viable network to share data. If this network contains flaws, it will have a direct impact on the planning of sales, the product development and the overall quality conformance of the products just to name a few of them.

Control over the value chain and access to data is not only important in terms of remaining competitive, but it is also demanded since regulatory requirements are incessantly increasing. This includes directives such as the Corporate Sustainability Reporting Directive (CSRD) and the Non-Financial Reporting Directive (NFRD). This means in practice that companies need to have more focus on internal control and be able to deliver reliable information in terms of quality control and sustainability, and not only financial information.

There are various approaches to remain competitive, oblige requirements and to have control over a company's products and services. One popular approach is Product Lifecycle Management (PLM) which involves efficiently overseeing a company's products throughout their entire lifecycles to optimize business operations. The ultimate objective of PLM is to increase product revenues along with reducing the product-related costs. PLM relies on the company's ability to share data and trace documents that are related to their products. Data that would be relevant to trace could for instance be product information and maintenance supporting information (Li et al., 2015). The amount of data tends to also increase due to new technologies and more advanced products. A lot of companies develop, for example, mechatronic products which contain a combination of mechanical and electrical parts along with software (Stark, 2022).

1.2 Problem Definition

Multinational companies that have been growing over time possess large amounts of data. This data is the core of the firm's product know-how and ranges from technical specifications to customer relationship management activities. To remain competitive in an ever-evolving business environment, it is critical for the firm to efficiently use its data. This enables cross-functional work throughout the organization and great interactions between the departments. However, there are various obstacles that could hinder these achievements. These could for instance be data-silos, a lack of unified data access tools within the value chain or a lack of knowledge regarding who needs

what information when. It is also difficult to keep the product variants apart from one another, which could lead to obstacles when trying to trace each component separately.

1.3 Purpose & Project Objective

The purpose of this master thesis is to get a better understanding of how information exchange in form of data plays its role both within and between business entities.

The project objective is to identify how data sharing in Product Lifecycle Management can enhance the business environment efficiency of a company.

1.4 Focus and Delimitations

When the term data is used, it refers to data related to products. This could for instance be blueprints, manuals and information regarding the location of the products. The thesis is not going to go into detail about what the data consists of numerically.

This thesis includes a case study of how Tetra Pak currently shares data between departments, business units, suppliers, and customers. The research will also briefly compare their way of sharing data with another multinational organization.

1.5 Research Questions

The problem and the objective that this thesis is going to address is divided into four research questions (RQs).

RQ 1: What are the benefits of expanding a company’s data flow to be more available to its business ecosystem?

RQ 2: What constitutes the risks of data breaches and how can they act as risk factors when expanding the information flow throughout the business ecosystem?

RQ 3: What are the financial benefits, such as cost reduction and revenue enhancement, resulting from PLM initiatives of data sharing?

RQ 4: Which are the different industry standards regarding data sharing in PLM?

The aim of these research questions is to give a nuanced answer to the project objective of this research.

1.6 Thesis Outline

Chapter 1 – Introduction: Context of the study is presented, followed up by the problem definition and the project objective. Finally, the delimitations are touched upon, and the research questions are formulated.

Chapter 2 – Methodology: Various research approaches are presented through literature, accompanied by research process and research preparation. Data collection in this project is then described followed by data analysis and research publication preparation.

Chapter 3 – Theory: The chapter begins with an overview of PLM, followed by the theory of how an organization can manage information efficiently. How information is shared through collaborations is then presented followed by digital debt and operations strategy.

Chapter 4 – The Case Company – Tetra Pak: The main case of the study is presented, accompanied by the structure of the organization and a relevant project that is conducted within the company.

Chapter 5 – Empirics: The collected empirics from the conducted interviews are presented. The empirics consists of product data sharing, protecting intellectual property and how product data sharing can act as an enabler. An external validation comments on how this can be transferred to another multinational organization.
Chapter 6 – Analysis: By combining the theory and the empirics, signs of digital debt are pointed out. Secondly, Hill's model is interpreted into the context of this research.

Chapter 7 – Conclusion: The four research questions are answered, followed by how the nature of the thesis could affect the outcome and its transferability. Lastly, ethical considerations, contribution to academy is evaluated and further academic research is suggested.

References: The sources that have been used for this project are referred to according to the APA 7th edition reference system. They are presented in alphabetical order.

2. Methodology

This chapter is going to discuss the methodology for this master thesis. The order of this section is supposed to reflect the whole process of the research. Topics such as characteristics of different methodologies will be touched upon as well as how research can be considered staunch in terms of quality. The working process of this case study research will be based on Yin's (2018) view. Other knowledge sources regarding methodology in certain areas are going to be used as well, with the aim of providing a nuanced and fair picture of how methodology is conducted in academia.

2.1 Research Approach

Methodology is necessary to perform a master thesis like all types of projects. It is the fundamental and systematic approach in terms of how the research was carried out. The methodology contributes to the master thesis by establishing the principles that are going to be complied during the whole process. The purpose of it is not to go into detail about exactly how it should be executed, but to act as a general guideline. Depending on the character of the master thesis and what objective/objectives it has, there are four different overall purposes of the methodology: (1) *Descriptive* studies that pursue to understand and describe how a research subject operates; (2) *Exploratory* studies which aims to understand a subject in depth; (3) *Explanatory* studies that investigate the causation and explanations of a research subject; (4) *Problem solving* studies that aims to find a solution to the identified problem of a research subject. A research project does not necessarily have to belong to only one category of the mentioned above, since a research project itself can be divided into several sub-studies. (Höst et al., 2006)

2.1.1 Different Approaches

The research methodology depends on the nature of the data collected, which in turn finalizes the research with its findings. The data can either be of

quantitative or *qualitative* character. *Quantitative* data consists of something that can be calculated, such as numeric scores and metrics. It can be used to find relationships between variables and predict certain outcomes through the art of mathematical statistics. *Qualitative* data on the other hand is descriptive and non-numerical. This type of data could be based on interviews and observations (Bhattacherjee, 2012). *Qualitative* data tend to be broader and richer compared to *quantitative* data, but not as accurate. To deliver a broad and reliable perspective of the *qualitative* data, it is important to look at the subject from different points of view. This is called *triangulation*, and there are four different types of triangulations according to Runeson & Höst (2008):

- Data triangulation: This is the practice when the researcher uses multiple sources of data.
- Observer triangulation: This type of triangulation is when the researcher uses more than one observer in the study.
- Methodological triangulation: If one is collecting both qualitative and quantitative data for the same research.
- Theory triangulation: This type of triangulation is used when the researcher is leveraging different theories or viewpoints for the study.

There are various approaches to make conclusions from the collected data. *Induction*, *abduction* and *deduction* are different research reasonings that can be applied when analyzing the data. *Inductive* reasoning is the approach when one looks at the observations for the purpose of developing theoretical conclusions. This is particularly popular when investigating a new area where there is a lack of established theory to begin with. *Deductive* reasoning is the most established research approach, which is based on formulating a hypothesis anchored from existing theory which is then tested and compared with empirical evidence. It is of great importance that the existing theory is correct and accurate when using this approach, since the research could otherwise make a false hypothesis seem to be correct. The third research reasoning, *abduction*, is the combination of inductive- and deductive reasoning. It is mainly common in practical research

and could for example be a study where a model is created by surveys which is then tested through interviews. (Nilsson, 2024)

2.1.2 Case Study

The empirical parts of the thesis will be a case study. Case study is the in-depth study and analysis of one or several cases, where one tries to impact the studying object as little as possible. It is primarily used to study certain phenomena, especially when it is difficult to separate it from its surroundings. The outcome of the case study is not necessarily applicable in general, since it is based on a certain case. It is only applicable to very similar cases which share common characteristics. This is due to the fact that the findings are not statistically significant, since it is not generated by a random sampling. An accurate case study is performed when the study objects do not share too many outer characteristics, such as educational background and position. Techniques that are commonly used in case studies are interviews, observations and analysis of archives.
According to Runeson & Höst (2008), there are three different types of research perspectives when conducting a case study. These are *positivist*, *critical* and *interpretive*. The first mentioned one, is when evidence is searched to test hypotheses. The second one has the pursuit of studying social critique which could be identifying cultural and social domination. The last one is the perspective of attempting to understand certain phenomena through the interpretation of the participants.

Due to the characteristics of how a case study is structured and performed, it will be the chosen approach for this thesis. The case study will have the perspective of interpretation, to evaluate the thesis partly from the participants of the study. Half-structured interviews will be performed, and they are subject to change, depending on the answers received from the interviewees. The findings in the literature will be compared to the interviews, and therefore complement one to another.

2.1.3 Thesis Approach

The objective of this master thesis is to describe how data sharing within a company and its business ecosystem is performed through a PLM point of view. The thesis will be based on interviews, academic literature and best practices which implies that the thesis will be of a *qualitative* and *exploratory* character. The gathered data will not be numerical and has the objective of delivering an in-depth understanding of the subject in question. The approach of this study is *abductive*, since the research is going to be based on previous studies within the field which is then compared to practice. Since triangulation is important in case studies which use *qualitative* data, *data triangulation* will be used. More specifically, it will consist of a combination of an extensive literature review, review of the archives and interviews which is displayed in figure 1.

Figure 1: Overview of the Data triangulation for the thesis

Yin's book Case Study Research and Applications (2018) and its approach on the process of conducting case study research will be the backbone for this thesis. The frame of this thesis will therefore consist of several different stages which are *Plan (Research approach), Design (Research process), Prepare (Researcher preparation), Collect (Data collection), Analyze (Data analysis)* and *Share (Research publication preparation).* Figure 2 presents this concept, which emphasizes the iterative character of this working process.

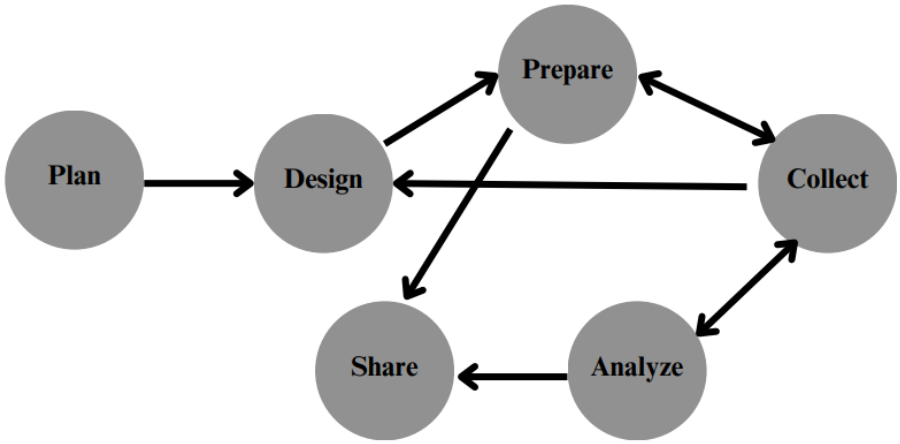

Figure 2: The case study process for this thesis (Yin, 2018)

2.2 Research Process

The production of knowledge regarding business research is accelerating while it is interdisciplinary. This makes it therefore important to do a thorough literature review to create a firm foundation, enabling to advance the knowledge and avoid making flawed assumptions (Snyder, 2019). The literature review assesses critical fields within the subject and points at directions where more research needs to be done. It introduces new perspectives of the research and ensures that the information it is built upon is relevant (Saunders et al., 2009).

Existing theories and research in the field of PLM and data sharing was acquired with the purpose of building a firm foundation.

2.2.1 Literature

The available literature was first used in the initial stage of the research project with the aim of justifying the research questions and the research proposition. Secondly, it was used to develop a theoretical framework that acts as the foundation for the interviews and discussion. Most of the literature that was used for this research are primary sources in the form of reports and scientific studies. Most literature concerns subjects such as PLM, data sharing, supply collaboration and cyber security. Literature was acquired through search engines such as LUB Search (the digital library of Lund University) and Google Scholar, where access was granted through licenses provided by Lund University. Figure 3 illustrates the literature review process of this project.

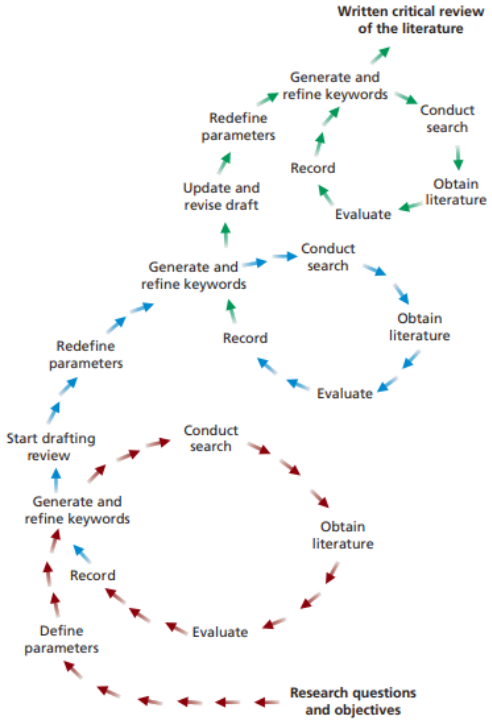

Figure 3: The literature review process. (Saunders et al., 2009)

2.2.2 Archives

Archives are generated through active and historical operations of a company. This could for instance consist of files, reports, plans and presentations that originally descended for another purpose than the research topic itself. It is of importance to be mindful of the document's original purpose when using it in a research project (Höst et al., 2006). The case company, Tetra Pak, has their own internal data collection system which is called Orbis. Employees within the organization have general access to the material on Orbis. Material from this collection of data was used as well in this thesis, mainly in the form of PowerPoint slides from previous projects.

2.3 Research Preparation

With the aim of performing a case study well, it is important that the researcher has the ability to ask good questions and to interpret the responses. It is also important to be flexible and react to different answers (Tellis, 1997). This is aligned with the perception that a case study should be flexible, for the purpose of changing questions during the period of the project (Höst et al., 2006). They further explain that the interviews themselves can either be structured, half-structured or open. Structured interviews are based on predefined questions that need to be followed thoroughly. Half-structured interviews consist of predefined questions that should only work as support during the occasion. Open interviews are when the interviewee itself gets to maneuver the interview.

2.3.1 Ethical Considerations

It is important to reflect on the ethical considerations when conducting research. Depending on what subject one is researching, there are various factors that need to be considered. According to Pearson, Albon & Hubball (2015), it is essential to treat the participants with respect and dignity during a case study. If one is going to conduct interviews to complete the research, it is of great importance to make sure that the interviewees grant consent to the researcher. Intellectual property and know-how must be protected, which can be

done through anonymity and a lack of numerical values in the details. It is therefore important that the participants sufficiently trust the researcher that they are transparent with their research design and use of data (Liang, 2020).

Conducting research close to a company can be very rewarding and provides opportunities to explore uncharted research territories. Interesting knowledge and information can be addressed accurately by discussing business processes with managers with hands-on experience. On the other hand, on that note, it is of importance to highlight that the research itself should not be compared to the work performed by consultants (Guide & Van Wassenhove, 2007). The research conductor is not employed by the company but performs the thesis for an academic purpose which is to deliver new insights of the subject to the academic world. Guide & Van Wassenhove (2007) claim in their article that "Academics should focus on problems in which consultants cannot engage because they require too much expertise and/or too much of a time investment to be profitable." (p. 534).

2.3.2 Research Kudos

It is important to reflect upon the credibility and trustworthiness of a study. Common questions when evaluating the quality of research are: Are the conclusions well founded based on the existing research done on the subject? Is data collection done correctly and is it trustworthy? Does this work maintain a proper academic level, or could it be influenced in some kind of way? Factors that come into play when answering questions like these can be divided into *reliability, validity and representativity* (Höst et al., 2006).

A study that can be duplicated and yield consistent results is considered to be reliable (Bryman & Bell, 2017). This is the contrast of research that is characterized by coincidental factors and chance. While Bryman & Bell primarily associate this concept with studies concerning quantitative data collection, they still argue that it is still applicable to qualitative research as well. They further extend the concept of reliability by categorizing it into *external* and *internal* reliability. *External* reliability is the ability to get the same

results despite conducting the research at another time or situation. Naturally, this is difficult to achieve in qualitative research, since it is dependent on the social environment. It is problematic to cover every topic and subject from interview to interview, since it depends on the interviewee and situation. One part of this research aims to study how data sharing differs between different firms. Hopefully, replicated research of this one results in similar collected data if the interviewee objects share similarities.
Internal reliability is the ability of how the researchers agree on how to read the collected data. This is mainly a concern when there are multiple researchers conducting the same research, which is not the case in this study. The internal reliability is therefore assessed to not be a problem in this thesis. (Bryman & Bell, 2017)

Validity depends on how accurate the measurements methods are. It concerns how useful and suitable the deduction is based on the collected data (Nilsson, 2024). Bryman & Bell explains that validity can be categorized in similar ways to reliability, which is *internal* validity and *external* validity (2017). *Internal* validity is to what extent the research is trustworthy in terms of cause-and-effect relationships. To make the research internally valid, it is important to rule out alternative explanations for the findings. With the aim of making sure that the thesis is internally valid, the supervisor of the thesis' writer is involved in processes such as theoretical framework and empirical data gathering. *External* validity refers to how well the outcome of the study can be applied to other cases. It affirmatively asks whether the results can be generalized to other scenarios. In terms of external validity, this research might fall short. The reason behind this is because the research is a case study. The findings are based on a specific case with adjacent targets. The findings are therefore only applicable to similar cases which share characteristics and are therefore only generalizable to a certain extent.

To what extent the conclusion derived from the thesis are applicable to the general is indicated by the representativity. The results and observations derived from the thesis can strictly only be applied on the population the data is

derived from (Höst et al., 2006). This implies that case studies are not applicable in general by their very own nature, which enables the research methodology to be criticized. Due to the time constraints of the thesis, there will be a limited number of interviewees which will limit the representativity of the thesis. Nonetheless, if the description of the context regarding the case is thorough, it is easier to transfer the findings on similar cases.

2.4 Data Collection in This Project

Multiple sources of data are of interest when conducting a case study, as discussed earlier. It broadens the perspective of the context within which the problem lies. As previously mentioned, this is called data triangulation which in this case consists of archives, literature, and interviews. Archives and literature are tools that help the research conductor to make accurate interviews with precise questions to touch the research questions. All information that was gathered during the master thesis was in its entirety of qualitative characteristics.

2.4.1 Archives

Company data was collected through various channels within the company. This includes internally held presentations done by the supervisor at the company as well as the manager of the PLM & Engineering Capabilities team. This helped the researcher to contextualize the problem and understand the actual need behind the thesis additionally. Information was also available through Tetra Pak's own internal database which is called Orbis. The gathered data from the archives were mainly assisting the work by broadening the understanding of the organization along with how the data is dependent upon different departments within the firm.

2.4.2 Literature Review

Most of the collected data in the beginning of the research process was collected through literature. Nonetheless, collecting data through literature is an

iterative process throughout the whole thesis. It is important to collect it during the whole process to broaden the perspective of the thesis as well as reaching depth in relevant fields. New areas of research might be discovered through interviewees, which in turn requires new data through literature with the aim of following up on those subjects. Eventually, the findings through the literature were compiled into a theoretical framework which was used to conduct interviews of quality and accuracy.

2.4.3 Interviews

The data collected from the interviews were conducted primarily in the middle of the research process. The people that were subject to be interviewed, the interviewees, were both chosen in collaboration with Tetra Pak and by the researcher himself. Prior to the interviews, interview guides were written which were of half-structured nature. The interview guides consisted of qualified questions which were based upon the conducted literature review earlier in the process. The interviews were recorded to not miss out on any crucial points and to enable the researcher to be fully invested in the interview at that point in time. Before this was done, the interviewees had to agree to be recorded. Before the recordings got deleted, they were transcribed by the researcher alone with the sole purpose of the research. The material from the interviews did not only complement the void in academic findings, but also illustrated and exemplified the academic findings. Every interviewee was asked if they could direct the researcher to anyone else for the purpose of increasing the possibility of connecting to more, unknown interviewee subjects that could be of interest to the thesis.

To be able to compare the applicability of the findings to other global companies, a final interview was conducted with someone who was not employed at the case company. This person works at an industrial company that is present globally.

2.5 Data Analysis

Data analysis is the process where one is discussing and discovering conclusions through a reflection of the data collected. The data can either be quantitative or qualitative in nature. This, in turn, results in the characteristics of the analysis and, with it, the conclusions differing in nature. Quantitative data analysis for instance has the main objective of identifying correlation and cause between variables. Qualitative data analysis, on the other hand, has the main objective of pursuing non-numerical information findings through words and illustrations to evaluate the meanings and experiences of people. As previously mentioned, qualitative data is going to be the sole source of data in this research. There are various tools to use to perform qualitative data analysis, which will be briefly discussed.

2.5.1 Qualitative Data Analysis

According to Yin (2018) there are four different general strategies to analyze data to execute a case study:

- Relying on theoretical propositions: The first strategy emphasizes the importance of relying on specific research questions to conduct data analysis. The data collection is dependent upon the research questions which in turn yields priorities when it comes to analyzing new data. (Yin, 2018)
- Working your data from the “ground up”: The second strategy is the opposite to the first one. By scouring through the data, concepts arise which in turn leads to an analytical path. When multiple analytical paths are discovered, relationships might occur which further deepen the analysis of the data itself. Inductive reasoning, previously discussed, shares similarities to this strategy. (Yin, 2018)
- Developing a case description: The third strategy can be considered of use if difficulties arise when trying to implement the previous two strategies. This could be particularly useful when a case study initially is lacking navigating research questions. This option might also be considered when there is a lack of useful concepts from the data. It

emphasizes the importance of organizing the case study according to a descriptive framework. By doing that, the context can be understood along with the factors contributing to the area studied. (Yin, 2018)

- Examining the plausible rival explanations: The fourth strategy is in some way a combination of the previous three strategies. A rival hypothesis is discovered when studying the theoretical propositions which in turn is developed through working up one's own data from the ground. Alternative explanations are therefore studied and evaluated. (Yin, 2018)

The chosen strategy for this research is going to be the first one: relying on theoretical propositions. Four research questions have been established in the very beginning of the master thesis which will guide analysis of the data. The questions will be broken down into sub-questions. These will be accurately targeted throughout the various interviews, resulting in a detailed and nuanced description of the topics.

3. Theory

This chapter will highlight the most relevant findings throughout the literature review. Product Lifecycle Management itself will be discussed from various perspectives, along with the difficulties and opportunities in managing the information of a company. Information sharing will also be a topic in this section, providing the benefits and obstacles that come with it.

3.1 Product Lifecycle Management

Product Lifecycle Management (PLM) entails efficiently overseeing a company's products throughout their entire life cycles, from conceptualization to disposal. It involves the comprehensive management of the product portfolio, that encompasses all associated processes and activities. The primary goal of PLM is to boost product revenues, optimize the value of the product portfolio, and minimize expenses related to the products. (Stark, 2022)

According to Ameri and Dutta (2005), the aim of PLM was to move beyond the engineering aspects and features of a product and to have an overview of the organization along with a shared platform of all the product related information. They claim that the ability to have access to the right information at the right time and context could be of reach through an integrated PLM-system. Further they argue that PLM results in a reuse of knowledge, ultimately closing the knowledge gap within an organization.

Another point of view is that the foundation of a PLM system can be likened to the cohesive force that binds activities. It constitutes a systematic amalgamation of technology and policies designed to effectively govern product data throughout the organization. Extracting value from product data hinges on a well-conceived PLM architecture. This entails the harmonious integration of data from diverse sources, facilitating seamless information flow and achieving interoperability among various systems. The key elements of PLM architecture

can be categorized into three main groups: PLM applications, Core systems and Business intelligence platforms. (Gutiérrez, n.d.a)

PLM applications, tailored to specific disciplines, generate essential product-related data encompassing information about sensors, software, and electrification in intricate products. For instance, Computer-Aided Manufacturing (CAD) stands as a representative PLM application. Core systems play a pivotal role in aggregating and consolidating data emanating from PLM applications. This category includes, among others, Customer Relationship Management (CRM) systems, Product Data Management (PDM), and Supply Chain Management (SCM). Lastly, business intelligence platforms facilitate data management, analytics, and real-time insights, delivering valuable information to inform strategic decision-making. (Gutiérrez, n.d.a)

3.1.1 The Phases of Product Lifecycle Management

To understand the wide definition and phenomenon of PLM, it is useful to divide the lifecycle into different phases. These phases are referred to as the Beginning of Life (BOL), Middle of Life (MOL) and End of Life (EOL) (Kiritsis et al., 2003). Each phase has its own activities that characterize the whole lifecycle of the products.

- BOL: This phase includes areas such as ideation, definition and realization of said products. This means that firstly the product exists only as an idea and grows to some kind of definition through tools such as Computer-Aided Design (CAD). This definition could be in the form of technological specifications and what components are required to realize the product. Manufacturing is then a core part of the BOL phase, since it is very complex in terms of Bill of Materials (BOM), Supply Chain Management (SCM) and Product Data Management (PDM). Enterprise Resource Planning (ERP) is also crucial to execute a well-planned production schedule. (Kiritsis et al., 2003)
- MOL: The second phase concerns areas such as CRM and support activities such as repairing the products and maintaining them.

Functions such as spare-parts procurement and distribution of the spare parts are also integrated in this phase. To execute smooth and efficient repairs of products at the facilities of the customer, it is necessary to maintain control and knowledge of what versions of the products that are currently being used. Sensors can also be applied to the products to follow the status of the products in real time, preventing a machine breakdown resulting in improved customer satisfaction at the price of increased complexity of information nature. (Kiritsis et al., 2003)

- EOL: The importance of the end-of-life phase has grown since the raised awareness of recycling and environmental impacts. Reverse logistics is the core of this phase, since it aims to reduce the harm to the environment by enabling recycling and material recovery. Directives such as the Corporate Sustainability Reporting Directive (CSRD) and the Non-Financial Reporting Directive (NFRD) have emphasized the importance of companies being able to report information in terms of quality control and sustainability, and not only financial information (Hahnkamper-Vandenbulcke, 2021).

The specific design of PLM systems varies based on the business processes they support. These business processes represent the structured sequence of activities undertaken to create a product, deliver a service, or achieve a business objective. Business processes are therefore essential to outline a company's operations. A simple task such as ordering a machine part for a customer abroad is considered a business process, since it is made up of a sequence of activities. To achieve a successful PLM system, it is necessary to document these business processes in detail. This enables not only rapid onboarding, but also ensures a company performs consistently with high-quality outputs according to their standard. Well-defined and documented business processes throughout the organization will give better insights, as well as enable potential improvements to be identified and implemented. The business processes should also be quantifiable and manageable, meaning that the collection of data is required to monitor them and determine whether they are performing well or not. Therefore, data collection is significant in the realm of PLM, as it serves as

the foundation upon which the PLM system effectively can operate. (Gutiérrez, n.d.b)

3.1.2 Knowledge Sharing Within PLM

Knowledge can be extracted from PLM systems, where the agents operating within the firm can gain insights which improves their day-to-day operations. The PLM system that possesses the knowledge is defined as a PLM knowledge base (KB) according to Ameri & Dutta (2005). According to them, the PLM KB does not necessarily have to be a physical centralized bank of knowledge, but perhaps an interconnected network of dispersed knowledge that is unified through various IT solutions. The PLM agents can then either add new information to the KB (TELL) or find answers for their questions (ASK), which is illustrated in figure 4.

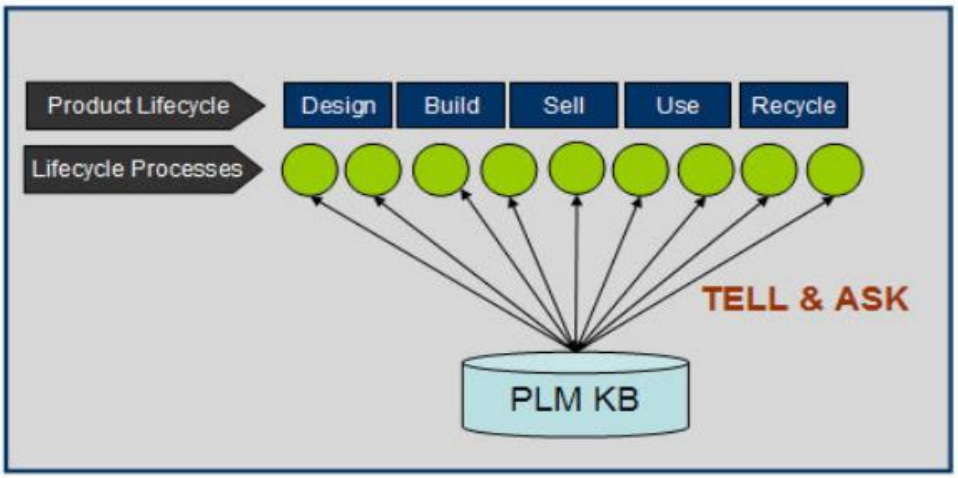

Figure 4: Overview of how the PLM KB can be used for either adding information or extracting information (Ameri & Dutta 2005)

By leveraging knowledge through information pools such as PLM KBs, it is possible to reduce the operational costs through efficiency when looking for information. Bottlenecks, such as searching for information instead of

contributing to adding value to the business, are reduced when using tools for information search. This eventually leads to an improved learning capacity which in turn makes the company more susceptible to innovations. This is illustrated in figure 5.

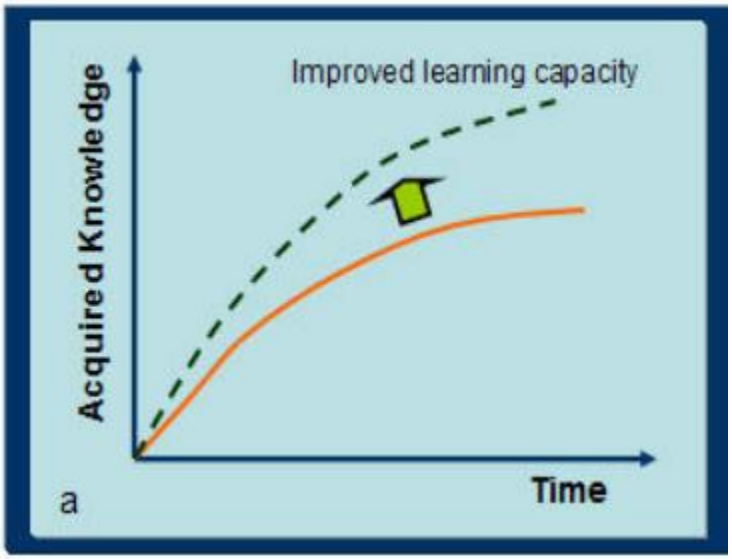

Figure 5: Illustration of how PLM can improve the learning capacity (Ameri & Dutta 2005)

Improved accessibility of knowledge has the potential to reduce the amount of time required to design new products or for instance perform service on a product at the customers' facility. This improves the efficiency of the business processes since it requires a shorter amount of time to perform similar tasks. This will primarily lead to a faster payback of the activity, but also decrease the costs. An overall improvement in the cash flow is therefore pursuable with improved accessibility of knowledge. This benefit is clearly stated in the article written by Ameri & Dutta (2005) shown in figure 6.

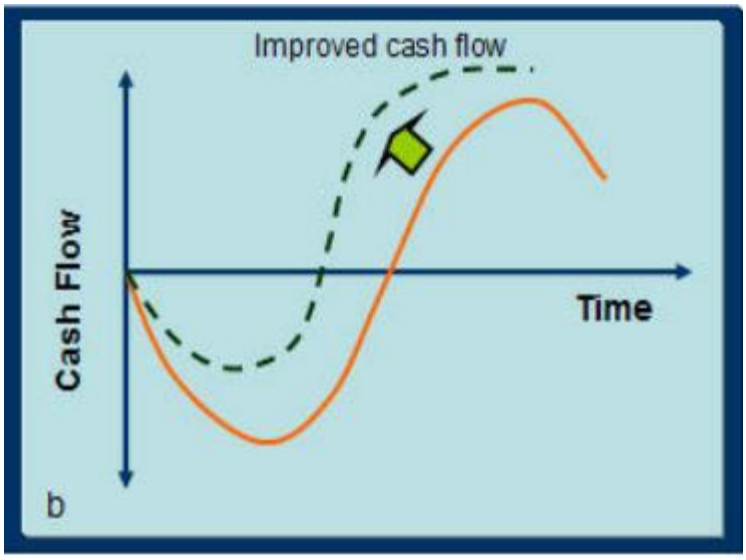

Figure 6: Illustration of how PLM can improve the cash flow (Ameri & Dutta 2005)

3.2 Managing Information

To advance the competitiveness within an organization, it is crucial to use the information and know-how efficiently and strategically. According to Xu & Quaddus (2013), it is difficult to quantify the value of a certain piece of information. This is because the value of the information depends on what context it is put into. The consumption pattern of the information also makes it more difficult, because data often has to be redefined to make it possible to interpret it into valuable information. Information also has various life cycles which could be difficult to forecast, since it is a challenge to predict the demand of information along with determining when it is dead information (being irrelevant or outdated).

For the purpose of processing and delivering the necessary information within an organization, information systems are used. They include all the components and data resources that are essential for the firm. Information systems in today's modern age are often referred to as computer-based information systems that

rely upon telecommunication networks (O'Brien & Marakas, 2011). O'Brien & Marakas further claim that these information systems are to be used either for serving the business operations or support the decision making (2011). They further explain that implementing ERP systems is an example of applying information systems, which in turn enhance internal efficiency and effectiveness.

However, there have been previous resource planning systems before the implementation of ERP systems. With the aim of understanding how information systems have developed to be as extensive as ERP-systems, it is favorable to study Material Requirements Planning (MRP) and Manufacturing Resource Planning (MRP II).

3.2.1 Material Requirements Planning

The roots of MRP-systems date back to the 1950s when General Electric and Rolls Royce were the first ones to computerize it (OptiproERP, n.d.). The aim of MRP is to plan activities to be performed to meet the objectives of the master production schedule. The foundation of MRP lies in the understanding of how products that are assembled or manufactured can be described by Bill of Materials (BOMs). This in turn describes the relationship between an assembly and its components. Using this, the demand for components and materials can be planned relatively simply through time intervals, such as weeks. (Halevi, 2001)

3.2.2 Manufacturing Resource Planning

Due to increased competition and greater customer demands, manufacturers had to become even more strategic in their manufacturing approach. This put higher requirements on their resource plannings systems, which ultimately lead to MRP II being developed in the 1980s to support their needs (OptiproERP, n.d.). MRP II is an extension of MRP, but it includes additional features such as quality management and machine capacity scheduling. However, it was still

lacking functions such as finances, accounting, and customer relationship management. This gave birth to the ERP-system that we know of today.

3.2.3 Enterprise Resource Planning

The digitalization and the opportunities it brings with it shapes the way an organization has to manage the business system. The ERP system is an important part of the IT-landscape, and it is therefore necessary that it is adapted to the ever-changing business environment. The software provider SAP defines ERP as the manager of an organization's core activities such as finance, manufacturing, supply chain and procurement. The IT-giant further explains that the ERP-system is often referred to as the system of record of the organization or even “the central nervous system of an enterprise”. This is shown in figure 7. (SAP, n.d.)

The selection of an ERP system will therefore be important for a company’s ability to remain competitive in a world full of change. Change that is driven by digitalization, increased requirements of governance and a need for a digital thread. The ERP-system will with that said play a large role in determining if the organization can carry out the necessary activities in the right way.

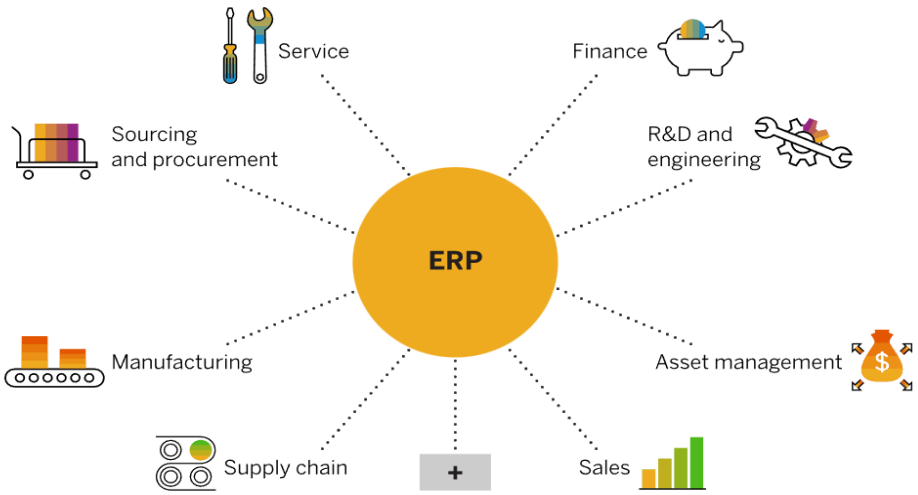

Figure 7: The components of an ERP system (SAP, n.d.)

3.2.4 Concurrent Engineering

Traditional product development is characterized by each stage of the development is completed before moving on to the next one. This could often lead to longer development cycles and potential issues that would not be discovered until later in the process, resulting in a stall of production. Concurrent engineering (CE) on the other hand, was introduced in the 1980s and 1990s with the aim of reducing the time-to-market. It was meant to improve the competitiveness of the West to remain competitive compared to other companies working in new ways, such as Toyota (Stjepandić et al., 2015). The fundamental characteristic of CE is to work on simultaneous tasks through cross-functional teams. This allowed organizations to work on different stages of the product development concurrently, which accelerated the overall process. The transparency within the company and its product development process made it possible for various departments to add value to the product at the same time.

As the concept of CE evolved, downstream processes became more involved as well. Activities such as service and disposal require the incorporation of the

customer early in the design processes. This built the foundation of the concept of Open Innovation, which means that customers, suppliers and Original Equipment Manufactures work towards realizing products that are beneficial for all parties. In this way, CE can also be used for the benefit of EOL, which in turn can be a step towards creating products adapted for a circular economy and sustainable service. (Stjepandić et al., 2015)

In the book Concurrent Engineering in the 21st Century the authors Stjepandić et al. address that achieving an effective CE is a challenging endeavor which requires demanding gradual evolution and accumulated expertise over years (2015). A systems approach proves to be beneficial to understand the interdependencies within an organization in combination with a clear vision from top management.

Stjepandić et. al further claim that CE is particularly important in the food industry (2015). They further highlight that a change in the packaging of a food product requires involvement of the package producer, the consumer and the production of the food item within the package. Open innovation is therefore something that occurs, since ideas might originate and be formulated by consumers or supply chain actors when consuming or handling the product, containing both the packaging and the goods within. Implementing these new ideas requires proper management, since it affects several key actors within the supply chain.

3.2.5 Design for Disassembly

There is a concept that shares characteristics with CE but focuses on activities concerning the EOL such as disassembly and recycling of components. This is called Design for Disassembly (DfD) and refers to when the disassembly and recycling aspects are considered when the product is designed. DfD especially relates to the ability to access or remove certain components from the product, while not damaging the parts or the product. Products have previously not been designed with disassembly and recycling in mind. This is because there has been little incentive for manufacturers to ensure the disassembly since Original

Equipment Manufacturers often do not recycle their own products. (Broughton, 2023)

However, the incentive for DfD has been growing larger now with legislations such as CSRD which emphasizes actions which are favorable for circular economy. As of today, the majority of DfD approaches have been developed for mechatronic products, which in turn consists of valuable components (Broughton, 2023).

3.2.6 Engaging With a New Resource

Large amounts of data have been generated at a swift speed since the invention of computers. With technologies evolving such as digital sensors, storing, communications and computing the means of collecting data has increased (Yaqoob. et al, 2016). Nowadays, we have technology in the form of computers to analyze much larger quantities of data while requiring a fraction of time compared to doing it manually (Big Data Framework, 2021). Thanks to the internet, data is also much more accessible as of today compared to when the world wide web was not a thing.

According to Brewis, Dibb and Meadows (2023), an improved knowledge within the organization is feasible through the leverage of product data. They further claim that companies can improve their market intelligence which in turn enables them to change their product portfolio to focus on where the actual potential is, instead of where it used to be. Utilizing the data enables data-driven decisions, which fosters great agility and responsiveness in the market. They also noted operational benefits from employing data tools, such as heightened customer retention, more customer-centric marketing strategies and enhanced customer experience. The insights enabled the companies to proactively identify issues and plan precise actions in advance.

With the aim of achieving this benefit, radical organizational changes were needed. If not, it could ultimately make them more vulnerable to data-led

competitors and make them less responsive to environmental turbulence within the business ecosystem.

However, implementing radical changes is not without any risks. It is important to maintain a balance between exploring data-related opportunities while at the same time not jeopardizing the current business operations. One step in the right direction could possibly be by hosting internally held projects when exploring new opportunities, which in turn would not harm the overall business performance of its stakeholders. (Brewis et al., 2023)

3.3 Information Sharing

Sun et al. (2005) defines information sharing as the activities that distribute information among multiple entities (people, systems, or organizational units) in an open environment. They further explain that information sharing itself should consider four questions which are: 1) *What* to share, 2) *Whom* to share with, 3) *How* to share and 4) *When* to share. But in today's context, with a lot of information being shared through the internet and risks of economic espionage, one could argue that a fifth point is how to protect.

It is also important to consider different information requirements. These can come from three different sources which are direct requests, collaborative sharing of requests and anticipations. Another similar interpretation of information sharing is that it is the activity where crucial information is given and received throughout the various members of the Supply Chain (Basana et al., 2023). It is the conveyance of information in the form of data to enable partners within the business ecosystem to respond as needed.

3.3.1 Collaboration

Collaboration in fields such as Supply Chain Management has become an increasingly important activity which has grown in popularity, which can be performed by two or more firms together. The reason behind this is simply

because the benefits, which could for instance be superior quality conformance, outweigh the risks (GEP, 2021). This is defined as Supply Chain Collaboration (SCC) and this form of collaboration can be categorized into two. The first one is horizontal collaboration, where two companies offering products with alike characteristics, i.e. competitors, are collaborating. There are several examples of horizontal collaboration and that is in the automobile industry. Numerous car manufacturers such as BMW, Honda and Daimler cooperated to improve components while at the same time competing at the global arena. This phenomenon is called coopetition. The second form of SCC is vertical collaboration, which is the phenomenon where suppliers and customers cooperate. This is more common and easier to implement than horizontal collaboration (Renko, 2011).

Even though SCC is not rare, and the benefits are real, the number of failures at implementing SCC is still imminent. Factors such as lack of commitment from senior management, lack of sufficient resources and the spread of limited resources across too many initiatives are contributing to the failure rate (Benavides et al., 2012).

To what extent firms decide to share information has a direct impact on the SCC. Raweewan and Ferrel (2018) investigated in their report how firms can reason when deciding to share information or not when collaborating with one another. By using a quantitative approach through payoff matrices, they were leveraging game theory in the form of Nash equilibrium and pareto optimality on scenarios such as prisoner's dilemma to provide insights on the topic. They found that if the information in question is a value-added component, which is similar to monopolistic knowledge that is lost when information is shared, game theory suggested that the two or three companies should in fact not share the information.

However, it was found that it is arguable to share information when the loss is lesser than the net benefit among the collaboration when sharing information. In other words, when the merged benefit of working together exceeds the

compared loss of working alone, companies should actually share information (Raweewan & Ferrel, 2018).

As elaborated, there are various rewards that can be achieved through information sharing. However, with rewards there comes risks. Nelson is discussing this topic in her report and further elaborates on how the fourth industrial revolution starts with trust (2016). This is explained due to the fact that the fourth industrial revolution heavily relies on the popular buzzword Industrial Internet of Things (IIoT), which are physical products or components that are connected through the internet. Since the level of connectivity between products is increasing due to this industrial revolution, trust is necessary between the user and the manufacturer of those products. This will in turn affect the relationships of the stakeholders, shareholders and partners as well. Nelson further explains that cyber-security is vital to ensure that trust itself is effective. Maintaining trust within the business ecosystem requires strong cyber-security capabilities, which in turn makes cyber-security a part of the core-value that is delivered to the customers.

3.4 To Outperform Competitors

The competitiveness on the markets have been growing, which is illustrated by the emerging industrial nations such as China and India. One of many factors that helps them grow has been the integration of functional perspectives into corporate strategy. It is therefore important for an organization to implement and manage digitalization, scheduling, forecasting etc. to achieve its long-term objectives and remain competitive.

3.4.1 Digital Development

When navigating forward throughout the digital transformation journey, it's crucial to aim for a state of "techquilibrium." This refers to achieving the optimal balance wherein a company possesses the ideal blend of traditional and digital capabilities and assets. This equilibrium empowers the business to effectively compete in an industry undergoing rapid digital revolution. If an

organization fails to pace the digital transformation by not implementing enough digital development, digital debt is evolved. The management consultant firm Triathlon defines this as when an organization lacks digital advancements in the recent past. This results in actions need to be taken with the aim of mitigating the risk of digital disruption, while at the same time performing the necessary tasks to maintain the business needs.

The opposite of digital debt, digital surplus, is defined as the excessive digital advancements in the recent past. This results in an excess of digital capabilities and assets that could either give a competitive edge or if unexploited, lead to inefficiencies.

In figure 8, it is illustrated how digital development depends over time.

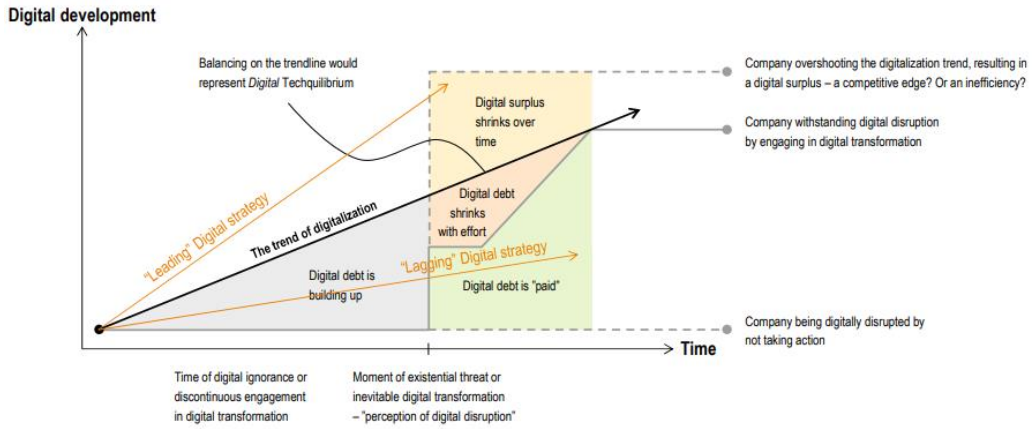

Figure 8: Pacing the digital transformation (Triathlon & Lund University, 2023)

3.4.2 Operations Strategy

Hill & Hill emphasize that it is of great importance to know that the market is driving the needs of an operations strategy. They further highlight that it is of great importance to understand the market through qualifiers and order winners. Qualifiers are the necessary attributes that a company has to possess to get onto

a market and remain a potential supplier to a customer. Order-winners on the other hand, are those criteria's that win businesses from other qualified competitors in the field. (Hill & Hill, 2017)

According to Hill & Hill, there are especially two important roles that operations can offer as part of the strategy that strengthens a company.

They claim that the first one is to provide operations processes that give an advantage in the marketplace. This could for instance be unique technological developments that competitors cannot copy. This inevitably leads to a market edge that in turn will distinguish the company from all the competitors.

The second role is to offer streamlined operational support that outperforms competitors in facilitating the key factors driving product orders in the market. Operations must strategically align processes and infrastructure with current order-winning strategies while remaining adaptable to future shifts in business demands. While many companies have access to similar technologies and infrastructure elements, the distinguishing factor lies in how effectively operations align these resources with the criteria that drive order success. Thus, operations serve as a cohesive response to business needs, encompassing all relevant aspects under its scope within the company. (Hill & Hill, 2017)

Hill's model highlights an iterative process where marketing and operations strategy come together around the qualifiers and order winners. Qualifiers and order winners are placed in the center of the model which is supposed to illustrate how it should be equally linked to both marketing and the operations strategy. This can be seen in figure *9*.

The marketing strategy is established which is supported by the corporate objectives. To qualify to participate in that market, certain characteristics are required of the product that is offered. These could for instance be the delivery speed, design of the product and the after-sales support. It is therefore very important that the qualifiers and order winners fit well with the operations

strategy that eventually will be responsible for fulfilling many of the important traits. If not, it might be necessary to change the strategy of operations or alternatively, refocus the marketing strategy so that it fits the capabilities of the operations.

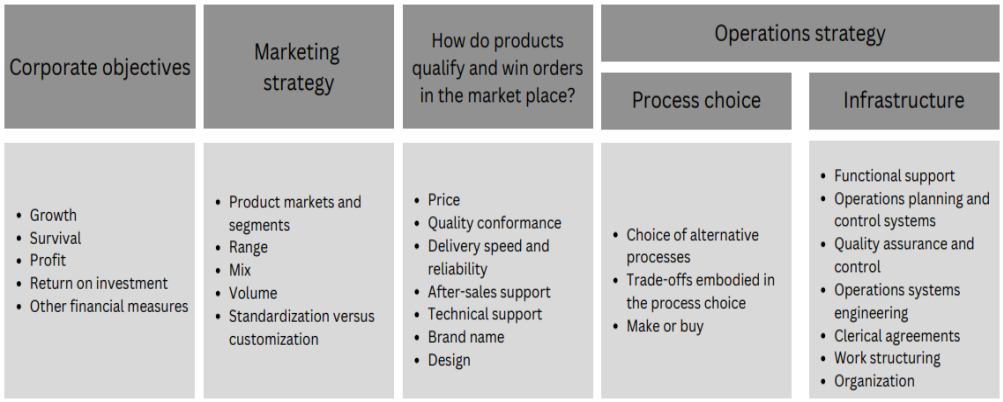

Figure 9: Hill's model (Hill & Hill, 2017)

4. The Case Company - Tetra Pak

The main case of this case study is the multinational food packaging and processing company Tetra Pak. This chapter is supposed to give the reader a brief description of how the organization operates along with the business units that the organization consists of. The strategic program Next Chapter System Platform (NCSP) will also be presented, which is central to Tetra Pak's ambition to take their information sharing to the next level.

4.1 A Glimpse of the Main Case

Tetra Pak was founded in Lund, Sweden, 1951 by Ruben Rausing (Tetra Pak, n.d.a). The organization has three different business areas which are packaging, processing and service. Packaging is the largest among those three categories, where they are designing and creating packages along with developing packaging machines. Processing concerns the development of food- and beverage machines, primarily for the dairy industry. The service area offers services such as maintenance and improvement of the customers' operations. As of today, Tetra Pak has grown into a global entity with a presence in more than 160 countries with its 23 000 employees (Tetra Pak, n.d.b).

Tetra Pak has been working with PLM for several years, and have strengthened their PLM group recently, with the purpose of remaining competitive and being able to respond to regulatory requirements. A critical part of their PLM-work is also to understand how they can manage their information flow and how they can benefit by data sharing with their stakeholders and suppliers more efficiently.

4.2 The Structure of Tetra Pak

As previously mentioned, Tetra Pak consists of three different business units. These are *packaging*, *processing* and *services*. The product portfolio of

packaging consists of filling machines along with packaging material. The manufacturing of the filling machines in question is primarily outsourced. The engineers of Tetra Pak collaborate closely with the suppliers when they are developing the filling machines. When the components of the filling machines are produced, they are then sent to a facility of Tetra Pak (where the facility of Lund is one of them) which are then assembled and tested. When the machine is fully assembled, it is then tested before it is sent out to the customers who ordered it. The business idea of Tetra Pak's packaging equipment is that they then offer the packaging material to the customers, which in turn generates cash flow for the packaging department of Tetra Pak. The packaging equipment of Tetra Pak is configured to order (CTO), which means that the product is specified by customer requirements and specifications to a certain extent.

The processing unit of Tetra Pak uses engineering to order (ETO). The processing equipment that Tetra Pak is selling is therefore completely adjusted to the customer's needs and requirements. This could for instance be the dimensions of the machines to make it fit the surroundings along with how all the pipes to and from the machines are located. The processing business also offers complete facility solutions, which for instance could be all necessary steps from milking a cow to putting the beverage into a package. The amount of in-house manufacturing is substantially larger in processing compared to the one of packaging. Processing also uses products from the packaging department to deliver complete solutions to the customer.

The third business unit of Tetra Pak, services, is built upon the idea of maintaining all the equipment at the customer base. All the different machines, facilities and equipment provided by Tetra Pak at the places of the customers are known as the installed base. Many of the products delivered by Tetra Pak have a long product lifetime, some ranging from 20 to 30 years. This makes it necessary for Tetra Pak to offer the service of those products, and therefore help the customers to extend the lifetime of their machines along with optimizing the productivity of the machines. This could concern replacing components of a certain machine along with complementing the entire solution with additional

equipment. The service unit maintains products delivered by both the packaging and processing side.

4.3 Next Chapter System Platform

The Next Chapter System Platform (NCSP), is a strategic program that aims to create the future technology and data foundation of Tetra Pak. It is a transformation process that will be ongoing for several years. The main initiative for NCSP is that their Enterprise Resource Program (ESP), which is SAP, of Tetra Pak is growing old. Tetra Pak is embarking on this transformation journey, which will upgrade the ERP system SAP ECC to SAP S/4. This will establish a standardized and harmonized platform that will enable the enterprise to be future-proof and ready for the latest technological advancements and business innovations. This initiative is driven globally and will affect the way the entire organization makes business decisions. (Tetra Pak, n.d.c)

5. Empirics

This chapter will not only introduce the reader to the necessary details about the interview subjects conducted for the research, but it will also present the findings from them. The most important activities and topics concerning product data sharing within the case company are presented. Finally, the security concerns both within the firm and outside the firm will also be touched upon.

5.1 Overview

The empirical material that is going to be the foundation of this research was collected through interviews. 13 interviews were conducted with one employee within the case company at a time, except for one interview which was conducted with two employees at the same time. Therefore 14 employees at Tetra Pak were interviewed during February and March 2024, holding various positions within the firm which is described in the following table. Each interview was semi-structured, which was tailored according to the competence of the interviewee. Appendix 1 illustrates how an interview guide could look roughly. Finally, an external interview was held in mid-April to provide feedback on the applicability of what was raised during the interviews at Tetra Pak.

Table 1: Interviews conducted for the study

Alias	**Experience**	**Date**
Interviewee A	Insights in PLM	15 February 2024
Interviewee B	Insights in technology intelligence and PLM	16 February 2024
Interviewee C	Insights in product development and PLM	19 February 2024
Interviewee D	Insights in managing product data	23 February 2024
Interviewee E	Insights in product data management	29 February 2024
Interviewee F	Insights in strategic PLM work	4 March 2024
Interviewee G	Insights in information security and legal affairs	5 March 2024
Interviewee H	Insights in data management	5 March 2024
Interviewee I	Insights in global product maintenance	5 March 2024
Interviewee J	Insights in global information management	6 March 2024
Interviewee K	Insights in information system platforms and reporting programs	6 March 2024
Interviewee L	Insights in supply collaboration	11 March 2024
Interviewee M	Insights in strategic product data management work	11 March 2024
Interviewee N	Insights in solution architecture within PLM	14 March 2024
Interviewee O	External validation with experience of R&D	15 April 2024

5.2 Product Data Sharing

Studying how a multinational company shares product data is a broad and complex topic, which doesn’t get easier by the fact that the firm has roughly 19000 suppliers according to interviewee B. There are also multiple software tools that are in use within the firm, which makes it difficult to get a deep understanding of each tool due to the time constraints of this research. Through

the interviews conducted within Tetra Pak, the most important activities have been highlighted regarding product data sharing both internally and externally. These are primarily the CAD-tools, the BOMs, the ERP-system, an application connected to the ERP-system and finally a strategic alliance partner.

5.2.1 CAD-Tools

The product is designed along with all the specifications and configurations in the beginning of the product life cycle. The product design is completed when the EBOM is fully finished. The journey to when the EBOM is complete varies and depends within the firm, especially if the product originates from packaging or processing. According to interviewee C, this is primarily because packaging has a lot of suppliers and therefore outsources a lot of their production while processing outsources very little in comparison.

When a team is developing a product belonging to the packaging side of the organization, there is an exchange of information between the engineers and the constructors of both the case company and their suppliers. This information exchange is an iterative process which is repeated until both parties are satisfied and believe that the information is complete. The software tools that are used during this process are mainly Creo and Windchill, which are both provided by the software developer PTC. During this stage of the product life cycle, it is of high importance to make sure that everyone is looking at the latest files. This roots in the fact that employees are sharing product data information through emails, excel-documents and PowerPoint-slides, according to interviewee C. This makes it in turn difficult to update product data, resulting in the possibility that colleagues are accessing dead information instead of updated and reliable information. The external validation through interviewee O claims that they experience similar phenomena in their operations. He continued to explain that a possible contributing factor to this could be that many systems are more updated than others, which in turn results in employees becoming comfortable in their ways of working with associated tools.

To overcome a part of this problem, the case company decided to create a channel to the suppliers for the packaging unit. This channel enabled the supplier to work on projects and files within the system of Tetra Pak using multiple firewalls. This was founded upon the idea that Tetra Pak would outsource much of the manufacturing concerning the packaging business. Interviewee C highlighted that this channel is still active, but there are different initiatives that could hinder the maintenance of this channel. These are mainly cyber-security concerns since the channel could work as a loophole to highly confidential information such as CAD-files that are not yet complete. This is a difficult situation, since the suppliers require those files to be able to complete their work. One risk that could be elevated if the channel is shut down, is that one has to extract the product information and send it to the supplier directly. This could potentially jeopardize the security of the highly confidential information since the case company loses control of the data to a certain extent as soon as it leaves the originating system. In turn, the supplier also has their own suppliers, which could possibly depend on the intellectual property of Tetra Pak. This makes it rather difficult to verify the actual security of third parties' systems, even though non-disclosure agreements could have been made and agreed upon.

According to interviewee J, there is a future solution for this obstacle. That is encryption that is delivered by a software provider, which enables Tetra Pak to encrypt confidential information that has to leave the firm. Keys are then handed over to the suppliers that require the information, enabling them access to the material. This initiative is one of many which belongs to a project called cyber resilience. Project cyber resilience has the purpose of strengthening the cyber-security of the case company with the aim of withstanding data breaches and protecting intellectual property. Interviewee O stated that the firm he works at already uses encryption where product data is then accessed through shared servers. He further explained that they never send blueprints through emails, since it could potentially jeopardize their intellectual property.

Interviewee C further elaborates the differences between packaging and processing solutions. Processing collaborates with their suppliers in a different manner compared to packaging. This is primarily because the amount of in-house manufacturing is substantially larger in processing compared to packaging. On top of that, processing also has made multiple acquisitions which has expanded their product portfolio and therefore discovered new areas of applications within the industry of food and beverage packaging. Interviewee M adds that these contributions have their own ways to define data and EBOMs which broadens the complexity of the topic. Previously, there hasn't been a complete willingness to fully integrate these small firms, as doing so would require a lot of work and effort and might downplay the small firm's best practice. Interviewee A agreed that the acquisitions are broadening the complexity of defining product data, but also added that it in some kind of way contributed to sub-optimizing processes of the case company as a whole. Since the case company consists of many different departments which make up the whole organization, each department is sub-optimized. They have their own management with budgets that are used to make the operations smoother for their piece of work. This sometimes results in the work not becoming smoother for other departments, but instead focusing solely on what concerns oneself.

Interviewee O commented that the complications in defining BOMs due to acquisition may not necessarily apply universally. Instead, he emphasized that in their case, the issue lay in how their acquisitions had structured their drawings, which were not as modern as the acquiring company. This resulted in the need for cleanup and ensuring that their drawing practices aligned with the latest standards.

However, now with the PLM-initiative of Tetra Pak that is strengthened by the upper management, a successive implementation is going to be conducted. This could for instance make sure that when someone is changing their CAD-software, they are switching to Creo and/or Windchill. Interviewee N added that in the future, all the PDM will be used through Windchill, which is a PLM-software provided by the company PTC.

Interviewee M continues his explanation that the processing business unit of Tetra Pak produces products according to the principle of Engineering to Order (ETO). This brings forth difficulties with standardization, since the processing solutions could vary greatly depending on the customer's needs and requirements. It is therefore perhaps not necessary to standardize all the previous documents, since that could bring forth costs that are very large in comparison to its utilization rate.

Several interviewees state that one challenge in harmonizing the information in the BOL, is that the packaging business unit is very CAD-centric when it comes to sharing and storing information. This could for instance be adding information such as tolerances to the blueprint. However, interviewee D states that it is sometimes necessary to do so. This is because some suppliers require that information on that document, which shifts the way of practice to do so.

Interviewee C further adds that when the data is complete in the engineering phase, it is then extracted and manipulated through Excel, and then stored in their ERP-system SAP. On the other hand, the processing business unit of Tetra Pak is not as CAD-centric in their way of practice compared to packaging. This inevitably means that they are storing and sharing information in different manners compared to the other one.

5.2.2 Enterprise Resource Planning

When the engineers and constructors are done with their project using CAD-software, they are then manipulating the data with optimized macros through Excel-files. The information is then transferred to their ERP system, which is provided by SAP. According to interviewee C the information is then data dumped into other monolithic systems which in turn results in unwanted effects. It is true that the information spreads and is stored within the company at several locations, but it makes it difficult to keep track of the information located at monolithic systems. This makes it more challenging to update it and make sure that the information is accurate. The externally interviewed

individual explained that they work extensively to prevent this from happening. Everything they do, at least in BOL, is uploaded to cloud solutions to avoid uncontrolled dissemination. This is reinforced by policies which are then dictating where everything should be saved. He further explained that of course, there are cases where it happens to be stored locally as well, but rarely.

When the product data is stored upon the ERP-system at the case company, it is always the latest version of the data that is accessible. The product data is then shared throughout the organization so that purchasing, service and manufacturing can successfully complete their tasks. It is also possible for chosen suppliers and service technicians to take part of the product information necessary into the ERP, through a peephole called Product Information Viewer (PIV) according to interviewee D.

5.2.3 Product Information Viewer

Product information viewer (PIV) is a product data tool. It is estimated that 9000 employees of Tetra Pak have access to this tool. Components, blueprints, master data and configurations of machines are a few examples of what can be found in the PIV. The packaging part of Tetra Pak is using it mostly. The ambition is that every employee should store their complete product data into this software, to store all the product data at the same location. The initial idea behind PIV was that the service technicians of Tetra Pak shouldn’t be required to use the ERP system to execute their daily tasks at the installed base. Instead, they would use the PIV which would work as a user-friendly interface which is receiving product data live from SAP. It would therefore contribute to an addition when it comes to transparency in Tetra Pak when it comes to searching product information.

PIV has a function that enables the user to download blueprints. This could for instance be necessary for a supplier, since they might want to know what component belongs to BOM in detail. This is read directly from the ERP, so it is therefore always the latest version. The risk that someone is then looking at product information that is not valid, is therefore eliminated. The material that

is stored at the PIV is classified as confidential, while the material that is under development is classified as highly confidential. According to interviewee O, in his organization, they also give access to partners to enable them to use configuration tools that are sales related. His experience regarding the limited sharing of the R&D part with outsiders aligns with how the case company operates.

5.2.4 Strategic Alliance Partnership

In 1991, Tetra Pak bought the company Alfa Laval with the intention to acquire the business part within Alfa Laval that is today processing solutions. Later, in the beginning of the 21st century, Alfa Laval was listed on the stock exchange. Interviewee L explained that it was after that when Tetra Pak started their alliance with them. One part of the success factors underlying the fact that they managed to start this partnership is because the Rausing family was the largest stock owner of Alfa Laval until 2023, with the number of votes of roughly 30%.

The products that Alfa Laval supplies Tetra Pak with are mainly separators, heat exchangers, pumps and valves. These components are used for the dairies and juice facilities that processing solutions are selling. Those parts are owned, developed and under the management of Alfa Laval. The strategic agreement between Tetra Pak and Alfa Laval is that Tetra Pak is the only sales channel for Alfa Laval to sell separators for boiling milk or processing juice. Alfa Laval is therefore not selling separators for the end customers in the dairy and juice industry. The responsibility of Tetra Pak is then to show Alfa Laval that they are covering market shares that both parties are satisfied with according to interviewee L. The packaging business unit is not covered in the partnership agreement, that is only processing solutions.

According to interviewee L there are different interfaces when Tetra Pak is interacting with Alfa Laval. In the BOL, such as the development of equipment, estimations are made regarding the order quantity to the partner. Requirements and decisions are made on a detailed level which are then sent to Alfa Laval.

This does not concern any detailed BOMs. Actions that are done on an operational level concern transferring sale documents. These are used in SBOMs. Spare components are also ordered and monitored which are required when performing maintenance of the Alfa Laval components.

In the strategic agreement it is stated that there is an exchange of product data between the two organizations. All intellectual property that belongs to the product, such as specifications, accrues to Alfa Laval. On the other hand, all intellectual property concerning applications and how to implement it to other components accrues to Tetra Pak.

Interviewee L continues explaining that during the development of the components there is an exchange of information, but it is nonetheless Alfa Laval that owns it and possesses most of the product data. Tetra Pak then accesses information that is crucial to complete their SBOM that they are then showing the customer. The product data that Tetra Pak can retrieve from Alfa Laval is from a portal that is connected to the system of Alfa Laval.

The motive behind the strategic alliance partnership between the two firms was that Tetra Pak was interested in separators for their dairy portfolio. The main advantage of the agreement is that Alfa Laval is getting high volumes in their production which in turn increases their competitiveness. That enables Alfa Laval to keep their production costs low, which is reflected in a lower price that Tetra Pak can contribute from.

Obstacles and conflicts of interests are natural in a partnership according to interviewee L. What was easy and straightforward when Alfa Laval was completely owned by Tetra Laval has changed since it was introduced to the stock exchange. They have their own objectives and global priorities which could to some extent affect Tetra Pak. Concerns and discussions regarding if the knowledge and know-how of Tetra Pak spills over to Alfa Laval occurs frequently. The risk would then be that customers to Alfa Laval would gain knowledge on how to apply critical components in their own solutions.

But at the same time, it is important to be aware that Tetra Pak has to share information with Alfa Laval to operate. For instance, a heat exchanger requires a lot of knowledge regarding application, which in turn sets demands on the product data that Alfa Laval possesses. To make sure that the information that is transferred to Alfa Laval stays within them, agreements are set to minimize the risk of information leakage. That can be both time consuming and resource consuming. It is a necessary evil to share critical information with other stakeholders, since it is needed but could potentially jeopardize the intellectual property of the case company.
The presumptions that are contributing to the establishment of the partnership, is that the game rules are transparent and clear. Interviewee L highlights that it is important that both parties clearly state what they can contribute with and why it is beneficial for both parties. One factor that plays an important essence of the partnership is that both firms are large players within their respective fields. Alfa Laval has their own sale channels that could work against the interest of Tetra Pak, but is dampened by the fact that Alfa Laval used to be fully owned by Tetra Pak.

5.2.5 Bill of Materials

According to interviewee K, there are five different types of BOMs that are relevant when studying the information flow within the organization of Tetra Pak. These are the engineering bill of materials (EBOM), the sales bill of materials (SBOM), the manufacturing bill of materials (MBOM), the as shipped bill of materials (ASBOM) and the as maintained bill of materials (AMBOM). The EBOM is relevant in the very BOL of a product, since that is when the engineers are defining the product. Interviewee K further elaborated that one major question within the case company is how the EBOM is going to be stored. As previously mentioned, the EBOMs of the packaging unit are very CAD-centric, which is then manipulated with excel until it is finally available in the ERP system. On the other hand, the PSE EBOM is more ERP friendly, which ultimately brings differences between the two of them.

Once the EBOM is complete and stored in SAP, the SBOM is created. It is essential to define what products are available to the customers and therefore has the purpose of serving the sales team. After that, the MBOM is created which is a comprehensive list of all the components, parts and assemblies that are required to manufacture the product. When the product is manufactured, it is then shipped to the customer which is described in the ASBOM. The EBOM, SBOM, MBOM and ASBOM are maintained and accessible through the ERP system of the case company. Interviewee N stated that it is very important to define who owns what BOM and that they are standardized, which is not necessarily the case now. This is because the case company has acquired many smaller firms, resulting in a lack of standardization when it comes to defining a certain type of BOM.

When the product finally arrives to the customer, an AMBOM is made. It describes how the service technicians are supposed to maintain and perform service on the product at the facility of the customer. It is also stored in the ERP system, but it is not as easy to control as the previous ones. This is because when the product arrives at the customer's location, the case company loses control of the product in one way or another. This is simply because the customer owns the product and now has it in their possession. It is likely that the customer makes minor changes to the product or uses it in ways that the case company is not aware of. If that were the case, it would then bring changes to the AMBOM which could potentially make it obsolete. This would in turn create obstacles for the service technicians when they are arriving at the customer's facility, realizing that the machine is different compared to what they thought. One way to tackle this problem would simply be that the customers notify the case company when they are changing something. However, interviewee I explained that this is not always the case. The customers are not obliged to report information regarding their machines- which makes it difficult to motivate them to do so. The interviewee further explained that currently they are using maintenance recommendations to perform service when it is required at the customer's facility.

Interviewee H added that it is important to know the limitations of what the company can treat as an intellectual property right. If there is a filling machine at the facility of a customer, and there is a read out regarding the speed or voltage of the machine, it belongs to the customer. That is inherent data that is coming out of their sub-component. The case company can take data from customers and add some additional information to it. By doing so, they can argue that the resulting dataset is intellectual property owned by the case company which enables them to take actions such as changing parts.
Figure 10 gives an overview of how the BOMs are transferred within the company and highlights the difficulties that are presented above.

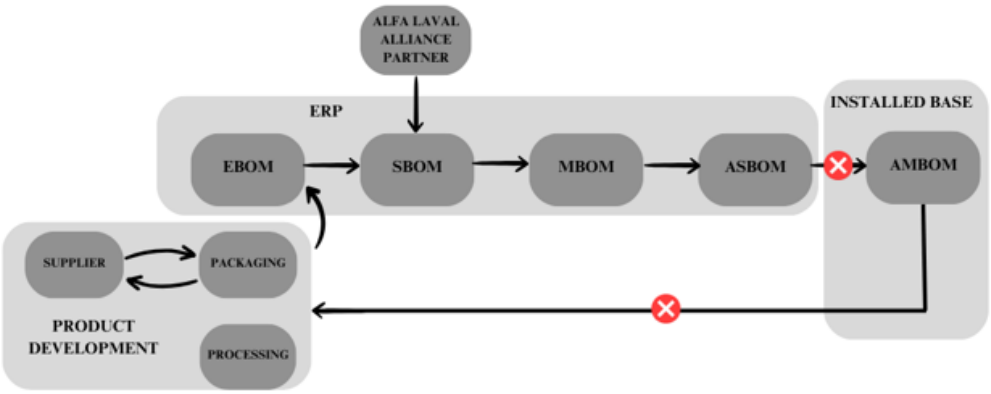

Figure 10: The BOM structure of the case company

Losing control over the product data when it arrives at the customer's facility is a common problem according to interviewee O. He explained that it also occurs within his organization that their customers are updating their products, without letting the manufacturer know. This particularly becomes a problem when it concerns a product category that has a long lifespan, such as 15-20 years. When they are selling products with a shorter lifespan, in the range of 2-3 years, it is more common that they have a more established relationship with the customer. Agreements are then made between the two of them that allow them to put sensors on their products, enabling them to know when they have to perform service on it.

5.3 Protecting Intellectual Property

It is important to protect trade secrets and know-how, while at the same time exposing them for the organization's benefit. With that said, the topic was addressed during the interviews as it is central to how a company shares and receives product data. The most important activities are treating files correctly and managing accesses.

5.3.1 Cybersecurity Concerns and Loss of Intellectual Property

When it comes to protecting the internal data, such as CAD-drawings, policies and common procedures are used to treat them and mark them correctly. Interviewee G further adds that when it comes to structured data in a database, protecting it often goes down to user access and protecting it from certain users. This is aligned with the interpretation of interviewee D, who also claims that a lot of the work when protecting sensitive data originates from activities such as determining who needs what access. Interviewee G continues explaining that it is of high importance to identify where it is a high risk- while also keeping an eye on the business development. It is necessary that the security is harmonized with the quick shifts of business demands.

When employees within the organization are sharing information within the company, there are rules and regulations depending on what you are emailing or uploading. If one tries to withdraw a file from the cloud, a note will be made which in turn has to be authorized by the manager before the employee gets access to it. Interviewee H adds that one other aspect that is important to keep in mind is that data moves from one system to another continuously like water. It has to be redefined for the purpose of suiting the business needs, otherwise it won't necessarily bring any value to the firm's activities. He then proceeds to explain the importance of how one decides to consume the data, since that impacts how the data should be redefined.

5.3.2 Internal Data Loss Events

Data breaches haven't happened at the case company, but data loss events have occurred which originate from inside-threats. Interviewee G further elaborates that these events are when someone has taken information from the case company. This could for instance be when people are downloading material from the company that they necessarily don’t need within the frame of their role. The solution to this issue is managing the internal access better, which interviewee D agrees upon. He elaborated that a cascade is created when one is breaking down the various accesses within an organization. It requires a lot of administrative work, which costs both resources and time. This administrative work is in its turn based upon the job description of each employee. That way, it is possible to figure out what accesses they require to complete their work.

5.3.3 Managing Accesses to Knowledge Bases

Managing the information and making sure that only the necessary people are getting the necessary information is a lot of work, which is a core activity in other organizations as well according to interviewee O. Managing the information at the case company falls under a project called cyber resilience which has been going on for several years. To regulate the users and their access to the PIV, the job description of the user is investigated to determine what information they require and not. It is the manager of the user that authorizes their access to the information provided. Customers are not granted access to the PIV and only a few suppliers are granted access. The reason behind that the customers are not granted access, is because it could potentially jeopardize and harm the intellectual property of Tetra Pak. This could for instance happen when they download blueprints and let another business manufacture the component needed. There are five different levels when it comes to the amount of material that the user can access. The access level that is granted to a user depends on the role of the user and what they require. The strategic partners for instance, which are basically suppliers that Tetra Pak closely collaborate with, will in turn provide their suppliers with information that originates from Tetra Pak. That information is not handled in the systems

of Tetra Pak, but it is often used within their own systems. This could potentially mean that Tetra Pak is losing control of their intellectual property and know-how to some extent. Formally, all parties have to sign non-disclosure agreements to safeguard the intellectual property of Tetra Pak legally.

5.4 Product Data Sharing as an Enabler

Sharing product data efficiently and securely is one major step in the right direction to implement a well-functioning and competitive PLM system. However, carrying through actions that ultimately lead to an efficient use of product data is often difficult. Interviewee C explained that the benefits from a functional PLM system, which depends on efficient product data sharing, are often difficult to quantify. Interviewee A added that there are multiple projects conducted at the same time within an organization or even a department, which makes it difficult to separate the benefits belonging to each and every project. Another dimension that broadens the complexity of quantifying the benefits of product data sharing in an initial stage, is that the benefits lie in what you are doing with the product data after it is properly managed. Interviewee C stated that “it doesn’t matter if you are building a highway, unless you can drive on it fast” as a parable in managing product data efficiently. The product data sharing itself should be considered as an enabler for further business cases which opens up opportunities for further projects. It is also important that there are standardized ways in performing the operational work that are benefitting the whole organization. It is necessary to not only see the PLM work as an IT-project, but a way of working and executing tasks in a way that is beneficial to everyone. This could for instance be done by ensuring that the employees are educated and receive a system understanding of their tasks.

5.4.1 Opportunities in BOL

If it is possible for the suppliers to extend the amount of work and access to the IT-system of the case company, an acceleration of the concurrent engineering within the case company could be feasible. This would reduce the number of copies regarding the product data that is currently spread to the suppliers, which

often consists of snapshots from the original product data sheet through e-mails and similar channels. That would in turn minimize the number of duplicates that possess the risk of being obsolete when updates are performed, leaving more room for accurate product data through a shared IT-system. If an employee of the supplier or the case company would change information on the shared platform, it would then be visible for all the affected colleagues within that project. According to interviewee C, this would speed up the time to give customers quotations and complete the product more swiftly. This, due to the simple fact that people do not have to waste time tracking the right document, or make sure that they are not working with an obsolete version of a certain document.

Interviewee F filled in that the suppliers, who do not necessarily offer design services to the case company, could also benefit from an extended sharing of product data in the BOL. Currently, blueprints and documents are often sent through snapshots, which are then marked with the requested information. This reduces the amount of information that could be reused, since it is done manually and not stored properly available for the suppliers. Interviewee F further elaborated that a factor that broadens the complexity of reusability, is that the characteristics of the packaging material (the paper of the packages), can vary depending on the moisture content and season.

There are not only opportunities that arise when sharing information to suppliers, but also when sharing more product data within the organization. Since the case company is a multinational organization, there are opportunities across different regions that are feasible when sharing more product data within the case company. Interviewee K explained that it is possible to expand the production capacity of certain products across the organization. This would result in a greater capability of exploiting the product portfolio throughout the different regions where the case company is active within. The interviewee proceeded to explain that if the BOMs and product data for a product is spread in a controlled manner, it would enable facilities to produce it independently. This could happen for example by extending product specifications and know-

how to different regions, enabling better market exploitation. In addition, it would have been possible to modify the products according to the needs of nearby customers. However, this places great demands on the standardization of product data and the sharing of knowledge. Clear guidelines on who is responsible for updating product etc. must also be established, to avoid conflicts within the organization.

5.4.2 Opportunities in MOL

As previously presented, there are challenges when sharing product data both to the business ecosystem and internally of the organization. As mentioned, one example is the obstacle to updating product data of the machine when it arrives at the customer's facility. If the case company would be able to retrieve data concerning the product at the site of the customer smoothly and regularly, the information loop would have been one step closer to being closed. According to several interviewees that is a favorable scenario, which opens up many business opportunities.

Improvements regarding the maintenance and service of the installed base would be possible if product data at the customer’s facility is retrieved. Interviewee E stated that it would be possible to do predictions for the service, which would enable the service technicians to change components tactically before the machine is completely shut down. Interviewee K added that if the case company can trace the products at the installed base (through AMBOMS), it would be beneficial for the BOL as well. It would then be possible to send recommendations regarding upgrades of components which could optimize the performance of the machines at the installed base.

Interviewee O agreed that having accurate information from the market is particularly important when developing new products. Inputs about the application and how it is used is quite useful when performing R&D. Even though information can be collected through test launches, it is beneficial to get information regarding how the products work in a larger time frame and how the manufacturing keeps its quality when producing larger quantities. However,

convincing the customers to let the manufacturer have systems that monitor the performance of the equipment in real time can be a hassle. It can vary depending on the market segment, relationship with the customer and the lifespan of the product.

Interviewee A explained an interesting business case that would be feasible if the AMBOMS were updated and accessible according to what the products look like at the customer's facility. If the case company knows detailed information about several customer's machines in a region, it is possible to create value between the customers, where the case company acts as a middleman. If there are two dairies with a relatively close distance between the two of them, and one of them requires maintenance while the other one has spare capacity- it would be technically possible to use the spare capacity to cover up parts of the other ones that missed out production. This would optimize the output of the combined capabilities, where there is a win-win situation. The dairy that has maintenance can still produce a certain volume of products while the other one is running at full capacity. That would also be beneficial for the case company, since they take full ownership of the processing solutions while they are also distributing packaging material to the facility that covers up for the other one.

6. Analysis

The purpose of this chapter is to analyze the empirical findings in connection to the literature review. This is done by applying theory from the literature, including digital debt and Hill's model to the empirical findings from the interviews.

6.1 Introduction to Analysis

After studying the content in chapter 3 and chapter 5, it can be observed that there are many arguments both for and against an expansion of unlimited product data. One thing remains clear, and that is that many opportunities reveal if product data is managed and shared optimally. Before achieving this, there are various obstacles that need to be addressed. These obstacles define the current situation for the case company, and one way to describe it is to see it as a digital debt that has been accumulated within the organization. If the organization succeeds in implementing initiatives to overcome these obstacles, the digital debt can be reduced. Once this has been accomplished, an interpretation of Hill's model is done, demonstrating that the company's operations strategy will be improved as a result. The improved operations make it possible to unlock new features of the company, making the organization more competitive.

6.2 Digital Debt

When studying the case company through the literature review and the multiple interviews, it became apparent that there is a possibility that digital debt has been built up throughout the years to some extent within the organization. As mentioned in section 3.2.4, it is defined as that the organization lacks digital advancements in the recent past and faces problems effectively addressing new information.

6.2.1 Signs of Digital Debt

When studying the collected data from the interviewees of the case company, it becomes clear that some actions and practices are not fully modernized and automized. As previously mentioned in section 5.2.1, it is stated that it is of high importance that everyone is looking at the latest and therefore relevant files. This originates from the fact that product data is transferred through emails, PowerPoint-slides and excel-documents. It therefore requires an extra workload to make sure that one is studying the material that is accurate and not irrelevant. Inaccurate information in the form of product data could act as traps that are costing both time and resources, which is being solved by double-checking the data through involved colleagues.

There are tools that are used to avoid traps like these, such as PIV and the ERP-system, but they are not used to their full potential and fullest extent yet. This can be explained by the fact that the case company has undergone multiple acquisitions, which deepens the complexity of how the organization is working with product data sharing. Acquisitions make it difficult to drive change among the functions of an organization. A result of this is that it could be troublesome to determine how aligned the departments and functions of the organization are in terms of digitalization and practice when it comes to sharing product data. Every firm before being absorbed by the case company had its own practice concerning product data sharing. This makes it difficult to integrate all the different functionalities within the case company and have a common standardized best practice when it comes to sharing product data.

Another aspect that is speaking for that there are signs of a digital debt, is that parts of the case companies' practices are CAD-centric. This makes it somewhat difficult to find certain information, since it occurs that it is accessible on CAD-files. As stated previously in section 5.2.1, it is sometimes necessary since the suppliers require that information in that manner. However, that can restrain how the case company defines product data and manages the accessibility of that information. External forces such as requirements regarding

how suppliers want to access information could therefore possibly inhibit digital advancements or aggravate the topic.

Furthermore, examples have been presented such as activities where employees are extracting information from an CAD-system to manipulate it through excel macros, which is then transferred into the ERP-system. According to an interviewee with experience regarding information systems and information management, that is far from best practice. This is because one wants to avoid manual extraction of information, which contributes to the risk of human error being the basis of mistakes. It is also possible that snapshots can be taken uncontrolled when the information is extracted from its platform. This in turn makes it possibly difficult to maintain a certain quality standard when product data is managed throughout the organization. It is therefore of high importance that there are standardized procedures that are enforced with rigorous information systems and digital tools. In this way, it becomes easier for employees to share information securely, while still maintaining high level of quality management.

Another aspect of this issue is that it makes it difficult to find the correct information at the right time. If employees extract information, it creates various data silos, to which not everyone has access. If the case were that all the people had access, it would remain difficult to be certain that the latest version is studied upon due to copies and duplicates of documents.

Figure 11 visualizes how digital debt could have been built up in the case company. The y-axis, digital development, refers to the digital mature level of the organization. The trend of digitalization on the other hand, refers to how well-adjusted digitalization is to the current needs. It is desirable for an organization to be on this line. Then the company has enough digital capacity to support activities in the best possible way. They then remain competitive and adaptive to continued change in the digital landscape.

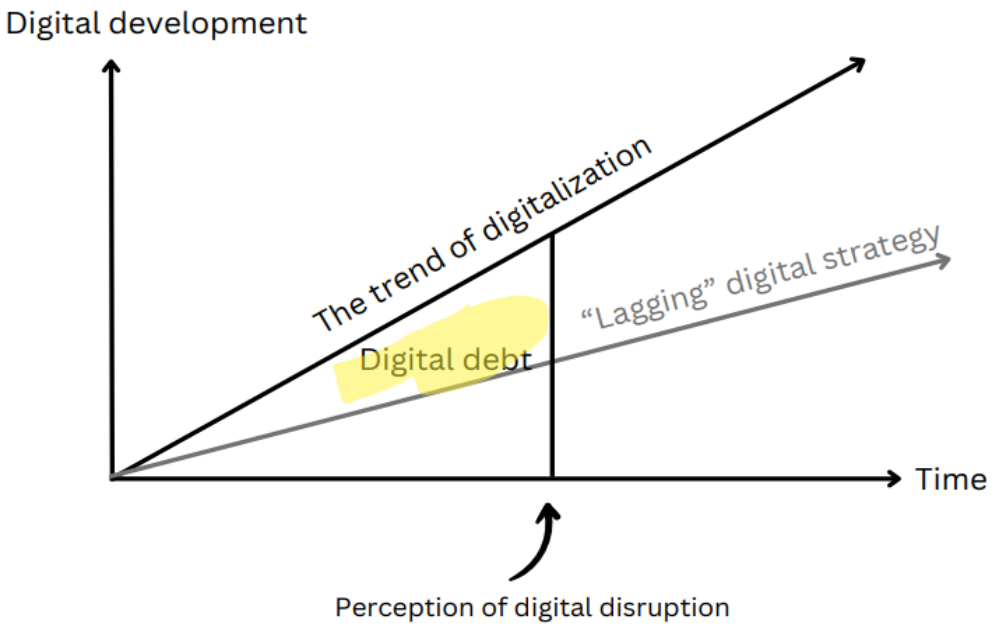

Figure 11: Visualization of how the digital debt has been built up

6.2.2 Dealing With the Lagging Digital Strategy

Throughout the collection of data, different initiatives have been brought up to surface regarding how the case company is trying to manage their product data better, both within the organization but also externally. One example of this is that the case company is going to leverage third party encryption to safeguard confidential product data when it is shared throughout the business ecosystem. According to interviewee J, it is also possible to use this encryption when sharing product data within the organization as well. Interviewee O further explained that encryption is already being widely used at other companies, which in turn implies that the case company lacks digital advancements in this area. It also indicates that it could be a type of solution that could potentially be an industry standard when sharing product data.

Another example of an initiative that is working towards closing the digital gap, is that when any part of the organization is changing their CAD-software, they

must change it to either Creo or Windchill. This initiative will work overtime, eventually resulting in the whole organization using one out of two CAD-tools which in turn standardizes procedures and the interface of the work.

Finally, the initiative of updating their ERP-system through the NCSP project is a leap forward to amortize the digital debt. The software will then be more accessible to standardized updates. This will enable the case company to use new features and tools which are a major part of their digital transformation, which is shown in figure 12.

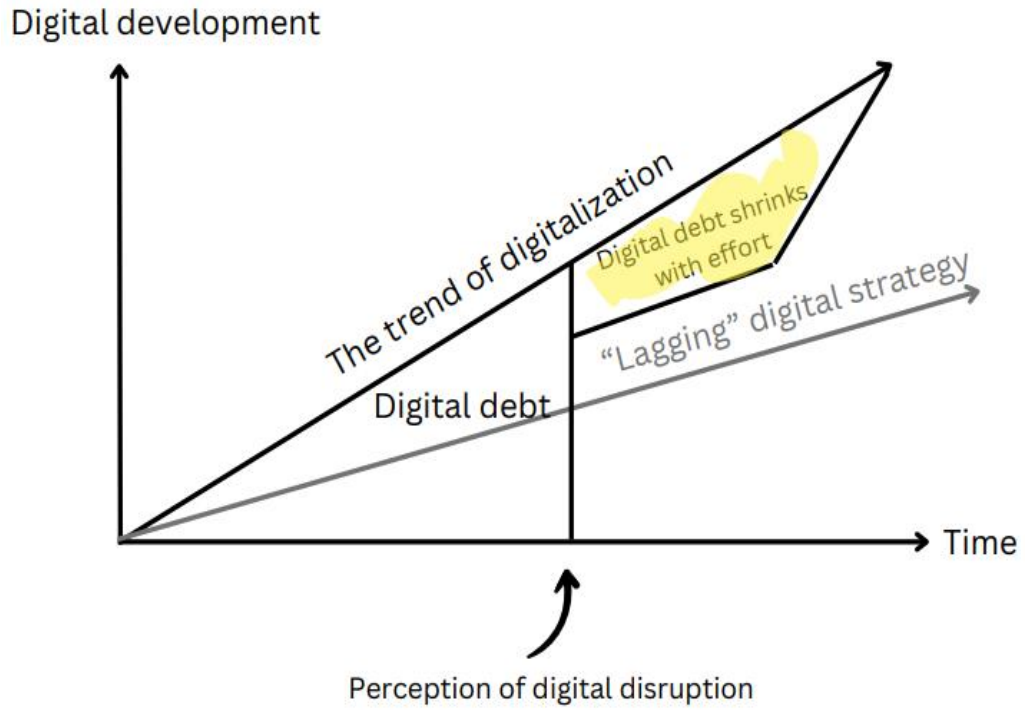

Figure 12: Visualization of how the digital debt is amortized

However, it is also important to nuance that the work will not necessarily rely solely on technical initiatives. As previously mentioned in the empirical data in section 5.2.4, part of the problem stems from that the case company is losing insight of the product data when it reaches the customer. This gets even more

difficult when the product reaches customers beyond the first one, through secondhand markets or similar.

Technical solutions may not necessarily be able to address this problem, so it may be equally important to consider other angles of incidence. These could for instance be able to build trust with customers and extend the amount of ownership of the products. It's important that there are incentives for customers to believe that the company can provide value if they have access to their product data, such as configurations made at their factories.

It is also relevant to discuss and nuance the problem that comes along when addressing the digital strategy. When tools are implemented and product data is standardized in new manners, old data that is documented and managed with previous tools will remain. The fact remains that you cannot necessarily handle all this information stored in the previous way, which in turn opens up new questions about what you should do with it. This can in turn affect the company organization on a large level, where decisions can be made to create subsidiaries to be able to handle this old information until it becomes no longer relevant.

6.3 Hill's Model

As a result of reducing digital debt, parts of the organization improve and become more efficient as it becomes better at managing product data. Studying Hill's model, this primarily relates to the operations strategy, as it is covered by aspects such as operations system engineering, work structuring, organization of work and trade-offs embodied in the process choices.

6.3.1 Improvement of Operations Strategy

When Tetra Pak has successfully addressed its digital debt, the company's infrastructure, as well as process choices, will have been improved. According to Hill's model theory, it is crucial that the operations strategy, corporate objectives, and marketing strategy are harmonized to provide the right

conditions for continued competitiveness in the market. This could possibly evolve to Tetra Pak being able to secure orders over other competitors in the industry through order winners. This is shown in figure 13.

The activities that are going to experience a change after the amortization of the digital debt are the operations systems engineering, work structuring, organization, but also trade-offs embodied in the process choice and functional support.

The plan for implementing encryption is an example of how the functional support and quality control is going to be improved. This will safeguard actions such as sharing product data to the suppliers but also to other parts of the company. Similarly, the transition of limiting the CAD-softwares to tools such as WindChill and Creo, is going to change the choice of the processes within the organization. Lastly, the wide ongoing project of implementing the new ERP-system through the NCSP is going to have a broad impact on the organization, in terms of how people are executing their daily tasks.

Figure 13: Hill's model with operations strategy highlighted

6.3.2 Reaping the Benefits

If the company would improve their infrastructure by addressing the digital debt which was previously elaborated upon, it may be possible to heighten the performance of the organization. Keeping the organization's size in mind, it is

safe to state that the case company is already qualified to operate on the market in the food processing and packaging industry. What is desirable is to be able to gain additional market shares and thereby secure one's position in the future. This can, for instance, be achieved by improving one's operations, leading to characteristics of the company that naturally win orders, rather than just qualifying for them. The question then revolves around how the company can use product data in a more efficient manner to achieve just that from a PLM point of view.
This can be achieved, for example, by successfully making improvements in delivery speed and reliability through concurrent engineering. When the infrastructure is enhanced by encrypting product data to suppliers for instance, concurrent engineering is achievable. This enables multiple employees to seamlessly work on the same project, thereby reducing the time to market for products. It's important to note that encryption, which securely disseminates product data, should be seen as an enabler. There is still room and opportunity for initiatives to be taken to realize the full potential of the technical solution itself.

Another point of view that could make the organization more competitive, potentially becoming an order winner, is after-sales support. From a PLM perspective, this involves the EOL of the product, which is somewhat problematic in the market and business environment in which the company operates. By having better control over the BOMs, which in turn is based on how one defines data and standardizes the way they are shared within the organization, both new business cases could be born, and current operations could be optimized. These new opportunities could involve predicting machinery breakdowns for the customer, thereby optimizing the product's value for the customer. Providing suggestions for additional equipment without needing to visit the customer and being able to learn from how they handle the product are also good examples.

Something that is not apparent in Hill's model as it was last updated in 2017 in the last edition of the book, is that it does not consider the latest directives on

sustainability reporting according to the European Union. The requirement for companies to be able to report sustainability data with a standard like how companies report their financial information puts significant pressure. The fact that companies must be able to deliver this to remain active in the European Union market makes it an order qualifier that is not mentioned in the model. The sharing of product data constitutes a fundamental part of being able to report for this directive, which will be necessary. Examples of this could be tracing various product components with their data in the value chain, upstream to suppliers, to access detailed information at the component level.

6.3.3 Straddling Legacy and Future

It can be challenging to introduce new ways for employees to carry out their work. Part of the effort lies in demonstrating clarity from the company's management about the importance of change, even if employees may feel comfortable with how they currently perform their tasks. In this case, it may involve individuals needing a holistic understanding of how their work and its execution impact other parts of the organization. It also advocates for the existence of some form of standardization in how information is reported and disseminated, which must be supported by policies and directives. Information and clarity on the matter are also necessary for employees to feel supported when they need to change their way of working.

One crucial aspect is how the company chooses to approach this strategically. If the decision is made to implement these initiatives mentioned in section 6.2.2, it is important to carefully consider the risks involved in their execution. A drastic implementation of the changes could jeopardize relationships with both customers and subcontractors, ultimately harming the company's survival. A safer and more manageable approach is to gradually implement changes in how product data is defined, shared, and the transition to new tools such as encryption, CAD programs and data storage methods. This could for instance also be accomplished through small internally held projects, which are then evaluated with the aim of learning how to implement them on a larger scale.

Another important consideration is how the company's legacy impacts the subject. Through acquisitions, the company has expanded over the decades with the aim of broadening market exploitation while absorbing new knowledge in the field of equipment for the food and beverage industry. If everything is standardized too quickly across these different market companies, one could argue that to some extent, the company is making itself blind. This blindness stems from losing the contacts and networks that the acquired companies had before being bought, which is dangerous.

Something that is naturally difficult is to successfully take proper ownership of the product once it has arrived at the customer. It is beyond the company's control to prevent customers from doing whatever they want with the products, which could include configuring them with the help of other solution providers. Additionally, numerical data belongs to the prevailing machine, such as temperature, efficiency and similar metrics. It is not obvious that the customer wants to share this with the manufacturer, which can also be a challenge to motivate them to do so. A step in the right direction would be to try to build, and mainly, maintain valuable relationships with customers. This allows the company to access data related to production, which can then be turned into a value-adding ingredient through additional solutions that can be offered through the case company's know-how and expertise. This is illustrated in figure 14 and is a desirable future.

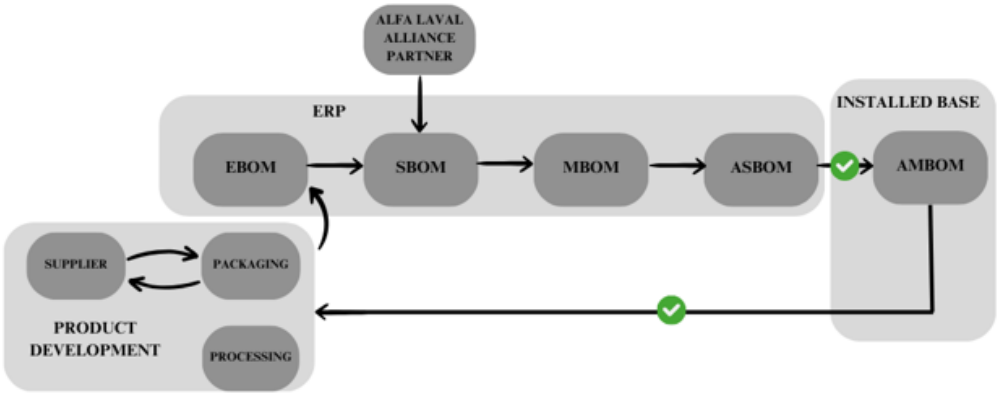

Figure 14: A scenario where customers share product data of the installed base

Finally, it can be concluded that the business models applied in the market make it difficult to fully take ownership at the end of the product life cycle. This is because the machines have a long lifespan, while also needing maintenance and supplies such as packaging materials.

If one is studying the subject of product data sharing within the business ecosystem from a circular economy point of view, it is important to highlight the role of detailed product data on a component level. Being able to access detailed information regarding how the components are structured and how they should be separated for proper recycling is likely to become increasingly important as regulations like the CSRD comes into effect. This is a sensitive topic that could be a competitive advantage, but it has the possibility to jeopardize the company's business since they are exposing their product data. For instance, it becomes easier for competitors to do reverse engineering if product data on a modular level is available for the customer.

7. Conclusion

This chapter answers the research questions that were proposed in the introduction through the findings. Followed, effects of delimitations, ethical considerations and the contribution to academia is presented. Lastly, future research areas are touched upon.

7.1 Research Question 1

What are the benefits of expanding a company's data flow to be more available to its business ecosystem?

The benefit of expanding a company's data flow to be more available to its business ecosystem is that new business cases open for the organization. This is because when product data is mutually more accessible to suppliers, between departments within the organization, and to customers, new opportunities arise that can take the company to the next level. In the case of Tetra Pak, one step in the right direction is the new implementation of an updated ERP system. However, it is important to not only rely on the advancement of one IT-project. It is important that it is harmonized with the practice of CAD-tools and the standardization of how the organization defines product data (for instance how to share and standardize BOMs). It is also important that employees of the organization possess the knowledge regarding how they should execute their tasks, so that it is favorable for the entire organization. For instance, some activities might require more effort for the sole employee, but it is possibly necessary to optimize the activity's value for the entire value-chain. Examples of his could include how to share information and where to store it, so that others don't have to spend time finding it.

7.2 Research Question 2

What constitutes the risks of data breaches and how can they act as risk factors when expanding the information flow throughout the business ecosystem?

Based on the collected empirical data, data breaches have not been assessed to be significant in this case study. This could be due to either the interviewees not encountering it, or this specific company not having suffered from it recently. It is also plausible that if it has occurred at the case company, only few people are aware of it. It is a sensitive subject to announce that data breaches concerning product data have occurred, since it can damage the reputation and brand of the organization.

What has been covered in this project is the potential risk of losing intellectual property and know-how when expanding the information flow concerning product data. This risk can be divided into three different leads, depending on where the product data is distributed. These are the following:

- Product data expansion to suppliers
- Product data expansion within the organization
- Product data expansion to customers

For the former category, the risk of intellectual property loss increases if one studies the suppliers in several stages. It is important to know how the suppliers access the product data that originates from the company and how they further manage the information with their suppliers. For the second category, the risk lies in individuals having unnecessarily excessive access to product data. This leads to all the intellectual property is centralized through individuals. The organization would then rely on that those employees not spreading the information carelessly. It is therefore important that access is maintained regularly, which are aligned with tasks of the individual. For the third category, the risk lies in customers using products and product data which could potentially harm the intellectual property of Tetra Pak. A possible example would be customers sharing information they have received from Tetra Pak with other competitors. Competitors that could benefit from product data

stemming from solution proposals, sales offers or reverse engineering. If the products of Tetra Pak make their way to unofficial market channels, it could also potentially jeopardize the brand if the equipment is faulty.

7.3 Research Question 3

What are the financial benefits, such as cost reduction and revenue enhancement, resulting from PLM initiatives of data sharing?

The financial benefits do not necessarily occur when only product data is shared, which makes them rather difficult to quantify. The benefit of sharing product data correctly is that new business cases are possible and within reach. In a multinational manufacturing company such as Tetra Pak, one potential business case would be that it is easier to maneuver a project with the aim of increasing the traceability of components. If product data concerning these components from the suppliers is accessible, it is easier to follow directives such as CSRD. Other examples of potential business cases that could possibly arise are extended concurrent engineering and more accurate control over the installed base. Those potential business cases could in turn enable the organization to grow more competitive on the market for food packaging and processing, allowing them to win more orders.

Through reasoning and interpretation of Hill's model, the improvement of operations strategy can support Tetra Pak's capabilities in the market, enabling them to become more competitive. These new business cases can elevate the operations strategy through improvements in work structuring, organization matters and functional support, to name a few of them. Additionally, it is possible for Tetra Pak to leverage their market size and experience through data driven decisions that are supported by improved capabilities.

Although numerous companies may have access to comparable technologies and infrastructure components, the differentiating factor lies in the effectiveness with which operations align these resources with the criteria that determine order success.

7.4 Research Question 4

Which are the different industry standards regarding data sharing in PLM?
Due to the time constraints of this project, only one case has been studied thoroughly with an external validation from an employee active in a multinational Swedish industrial company. The answer to this research question, based on the circumstances, is that companies may have both similarities and differences in how they choose to share product data. This is characterized by their relationships with their customers and suppliers, as well as how the make or buy choices have been made.

7.5 The Effects of Delimitations

There are constraints on how applicable the findings of this research are since this is a case study. Due to the limited timeframe of this project, only one case company has been thoroughly investigated through the interviews. The transferability of the findings is primarily to other multinational organizations, who provide services to products which have a long lifetime.

The findings rely on the conducted interviews, which affects the external reliability. It is therefore naturally difficult to retrieve the same findings, since it relies on the social environment which depends upon the experiences of the interviewees. However, parts of the empirical data have been confirmed by an external validator, who claims that some parts strongly resemble their own experiences.

7.6 Ethical Considerations

The empirical data that has been collected for this project has only been in possession of the author. In addition, the transcriptions of the recorded interviews are deleted by the time the thesis is published. The interviewees have been anonymized with the aim of not exploiting them or their interests. All material that has been published has been approved by all parties involved, with the aim of avoiding breaches of confidentiality.

7.7 Contribution to Academy

This thesis explores how a multinational manufacturing company can take advantage of sharing product data, which is illustrated in figure 14, while evaluating the risks that comes with it.
The study builds upon a significant portion of existing literature and research, which in turn could improve the understanding of it. It also demonstrates how one can analyze empirical data through the interpretation of theory by problematizing the subject within a context.

The research has also problematized areas such as the Corporate Sustainability Reporting Directive with subjects such as PLM, Circular Economy and Operations Strategy in the realm of product data sharing. In this way, the work has also contributed to a nuanced understanding of how these various complex topics interact with each other. But also, how companies can benefit from them on the path to a constantly evolving business environment.

The study also provides a foundation in the field for academia, thereby creating space for new areas to be further explored. In this way, new opportunities and question are opened for further consideration. That would allow us to learn more about how companies interact with each other and how the interaction will work in the future.

7.8 Future Research

This research has explored how product data sharing can be used by studying one case company. With that said, it would therefore be of interest to study how other multinational organizations are receiving and sharing their product data. If this had been done to a greater extent, interesting correlations might be unveiled. This would then contribute to the understanding of how companies operate together and rely on their business environment. In the context of this research, it primarily tangents RQ4.

Something that could also benefit from future research is how other multinational manufacturing companies are assessing the risk of data breaches and losing intellectual property. This could, for example, be accomplished by collecting quantitative data from several different companies where they can share their insights into the matter.

This research does not include any interviews with customers of the case company. It would therefore be interesting to study the subject from a customer's point of view. That would contribute interesting insights regarding how they would benefit from an extended amount of product data from the supplier and how that would affect their decision when performing procurement. In this way, it may be possible to quantify customers' willingness to pay. This, in turn, enables them to receive detailed information about their purchased products, which affects the manufacturing company' order winners and order qualifiers.

Lastly, it would be interesting to study how firms operating in the EOL rely on product data when they are disassembling the products for activities such as recycling. It would be particularly interesting to see how they would benefit from DfD and how the correlated product data is transmitted throughout the entire value chain.

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Appendix

Appendix 1 - Interview guide for employees at the case company

Introduction

- I appreciate that you take the time to talk with me and help me to complete my master thesis.
- Introduction of what my research project is about.
- Do you consent that this interview will be recorded?
- Do you want to be anonymous for this interview?
    - If so, to what extent do you want to be anonymous?

Background of the interviewee

- Would you like to describe your role at Tetra Pak?
- What are your prior roles and responsibilities?
- Do you have any experience about PLM outside of Tetra Pak?

Benefits of Expanding Product Data Flow

- How has your organization expanded its product data flow to the business ecosystem, and what motivated this initiative?
    - In your experience, what are the observed benefits of increased product data availability within the business ecosystem?
    - Can you share specific examples of how product data sharing has positively influenced collaboration, innovation, or decision-making process?

Risks of Data Breaches

- How does your organization address data security and privacy concerns when expanding information flow in the business ecosystem?

- Have you encountered any data breaches or security incidents related to increased data sharing? If yes, how were they addressed?
- What, in your opinion, are the potential risks and vulnerabilities associated with data breaches in a business ecosystem?
- How do these risks influence decision-making regarding the extent of information flow expansion?

Financial Benefits of PLM initiatives

- Can you provide examples of how PLM initiatives, specifically data sharing, have or can contribute to cost reduction within your organization or within the business ecosystem?
    - How are the financial benefits resulting from PLM initiatives, such as cost savings and revenue enhancement, measured and quantified?
    - In your experience, how do these financial benefits vary across different stages of the product life cycle?

Industry Standards in Data Sharing

- How does your organization ensure compliance with industry standards related to data sharing in PLM?
    - Are there specific industry standards that heavily influence or guide data sharing practices in your field?
    - How do these standards impact the design and implementation of PLM initiatives within your organization?
    - Have you encountered any challenges or conflicts related to industry standards when expanding data flow in your business ecosystem?
    - In your opinion, how flexible are industry standards in adapting to technological advancements and evolving business needs?

Closing

- If possible, could you describe or illustrate how the company shares information both within and outside the business?
    - If not, could you perhaps describe how your department shares and relies on information?
- Do you have anyone in mind that I should contact in order to gain other perspectives on these questions?
- How would you address these questions if you were me?
- Thank you for your time. If you have any questions or concerns regarding this interview or my research in general, feel free to contact me.